Report on the Performance of the Lion Intoximeter 3000 and the Camic Breath Analyser evidential breath alcohol measuring instruments during the period 16 April 1984 to 15 October 1984

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and
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with a Foreword by

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QUEEN ANNE'S GATE LONDON SW1H 9AT

23 May 1985

Dear Sir William,

I have read your preface to the Forensic Science Service report on evidential breath testing with great interest. I am most grateful to you for the continuous care you have taken in monitoring the Forensic Science Service work and for your lucid assessment of the scientific issues.

I think it right, before reaching firm conclusions, to tell you of the action I am minded to take, having studied your preface and the report, and to check with you that it is consistent with your scientific findings.

The main conclusion from your survey – that the Intoximeter and Camic equipment and procedures are fundamentally acceptable in the sense of not placing subjects unjustly in jeopardy – confirms that these machines and procedures should continue to be the principal means of assessing for evidential purposes whether a suspect's capacity to drive is impaired by alcohol to an extent which justifies criminal proceedings.

The fault which this study has identified in the acetone detector clearly requires correction. Although this fault leads to under-estimation of the level of acohol in occasional cases and therefore does not lead to wrongful conviction, it is necessary in the public interest to modify the machine to correct this fault. I shall require the manufacturers to make the necessary modifications. I also have it in mind to have the machine modified so that if the difference in the readings between two successive breath samples exceeds 20% the machine will abort with the consequence that any evidential testing will need to be by way of blood test.

I note that the extensive tests undertaken produced no evidence of the frequent occurrence of interfering substances in breath tests, and that the combination of properties which would be required makes them in any case unlikely. The possibility of rare instances, such as from solvent abuse, does not seem to justify in itself the introduction of special procedures, given that anyone affected has the opportunity so to inform the police and, if necessary, the court.

I intend to continue the non-statutory blood test option while these modifications are being made, and to allow time for your findings as regards the intrinsic acceptability of breath testing procedures and machines to influence public opinion. I would however be reluctant to continue indefinitely to offer as a matter of routine an option which is not likely to produce a more favourable result to the suspect, and which merely prolongs and complicates the proceedings, unless there were some scientific justification for retaining it.

I was interested in your analysis in paragraph 11 of your preface of the relationship between the severity of penalty and the extent of precautions which are necessary to minimise risk of wrongful conviction. As you know, the penalty for driving with a level of alcohol above the lawful limit includes mandatory disqualification as well as other penalties. I do not regard such penalties as inappropriate or unduly severe given the death and injury which so often results from driving while impaired through alcohol. While recognising that the greater the impairment the more severe the penalty should be, I am not clear that your scientific findings point to a need for a change in the law or structure of penalties for drink/driving offences which already afford wide discretion to the court.

The investigation which you have supervised will contribute to a clearer appreciation of the scientific basis for evidential breath testing as well as to a better understanding of the equipment and procedures. The improvements in the equipment which are called for, though minor, will further improve effectiveness. I believe that the action I have outlined in this letter is consistent with your scientific findings, but I would be grateful for your confirmation before reaching definite conclusions.

Yours sincerely

(Leon Brittan)

13 Staverton Road, Oxford

Oxford 58355

3 June 1985

Dear Home Secretary,

Thank you for your kind letter of 23 May.

You take up two questions that I raised in the preface: (1) the continuance of the non-statutory option; and (2) possible reconsideration of the relationship between penalty, chance of wrongful conviction and chance of wrongful escape from conviction. May I say at once, and using my jargon, that while I am professionally familiar with the effects that a given dose of some drug will produce, I have only a layman's knowledge of what effects follow from a given "dose" of legislation.

(a) As to the first question, it would be a great step if the acetone detector defect were remedied; and I would welcome your proposal about large breath differences. Apart from general arguments, that leaves only the risk of interfering substances. After reexamining the evidence, given for instance in Tables 11, 12 and 13, and the physicochemical limitations that I briefly outlined in paragraph 7, I am bound to say that the case for retaining the non-statutory option seems to me weaker than that for its withdrawal.

(b) As to the second question, I am glad of this opportunity to make myself clear. In the analysis mentioned in paragraph 4, I was struck by the fact that one effect of the procedures used was that with subjects who gave a lower breath result of 39μg, over $\frac{4}{5}$ths would have blood-levels not merely over the limit of 80mg, but over the prosecution limit of 87mg, with some of them considerably higher. It seemed to me unfortunate that subjects could become quite significantly intoxicated, be tested, and not be proceeded against. They would learn the wrong lesson.

I wholly share your concern over the death and injury arising from drunken driving, and began to wonder how the legislation had come to allow so many people who had clearly been drinking to a degree which is likely to impair their driving to escape prosecution. One possibility was that what one may call "unjustified non-prosecution" flowed from that very concern, combined with an equally strong wish not to convict unjustly. For severe penalties will then be bound to carry such protections as will inevitably allow "unjustified non-prosecution". In raising the question of the balance, I was hoping that it would be examined and discussed, rather than pressing for a change in legislation now. The discussion would involve people's perceptions as well as forensic and criminological considerations.

I think it is also necessary to recognise that as medicine manages to improve our lives, mortality and disability from traffic accidents will steadily come to bulk proportionately larger, and will therefore be regarded steadily more seriously (as has happened to other hazards) as the years roll on. On further reflection, I incline to think that lowering the limit (from 80mg blood to 50mg, say) might be a more straightforward next step than trying to combine a revision of the allowances with revision of the penalty structure. Before any such steps are taken, I would hope that the problem of "unjustified non-prosecutions" as well as that of "unjust prosecutions" is debated more fully.

If one returns to your second question, it is clear that in raising it, I was straying from my strict brief, and looking beyond present legislation to a new pattern that would only be arrived at after lengthy debate and a longer experience of the present relatively new procedure. I am concerned at the evidence that has emerged about "unjustified non-prosecutions", but it certainly does not itself provide a basis for revising the penalty structure now.

Yours sincerely,

William Paton

(Sir William Paton)

FOREWORD

1) Introduction

The Home Secretary, after commissioning the Survey, whose results are presented in the following Report, asked me to provide an independent scrutiny of the procedures to be used and of the results obtained. The outcome of that scrutiny is now presented in the form of a foreword to the main Report, and should be read with it. I have taken the word "independent" to mean that I need to keep in mind the separate interests of at least three groups: first, the defendants in cases involving evidential breath tests, with especial concern for the risk of incorrect conviction; second, the public at large, especially as to the question of whether its interest in the control of drunken driving is being satisfied; and third, (in the light of some of the public discussion), those charged with implementing the procedures concerned, particularly as regards their entitlement to informed comment as to competence and skill.

Although I have worked and taught for many years on various aspects of the pharmacology of alcohol and on alcohol dependence, I had had no direct experience of breath-testing or alcohol-related traffic offences, apart from service in 1956–8 as a magistrate. I am particularly grateful, therefore, to the Chief Constable of Gwent and his staff for their help and information. They shewed me their procedures, and gave me simulated road-side and Intoximeter breath tests, using mouth wash-out with sherry to obtain positive results (which incidentally verified the rapid elimination of mouth alcohol). I am also much indebted to Professor Vincent Marks, of the University of Surrey, for valuable discussion, and for arranging a meeting with a number of interested parties. To this I have added a wide range of informal personal enquiry. Finally, the Director of C.R.E. and his colleagues have been most cooperative, in answering many questions, showing me their methods (all of which appeared to me of a high scientific standard), and providing me with an extensive bibliography and much other information.

Normally, I would have discussed with the Home Office a draft of my comments, in order to avoid mistakes and to ensure that all the important issues were taken up. In this case, however, the need for independence was such that this foreword has been prepared with no comment or criticism of any kind from the Home Office or other party involved, apart from agreement on format, and a few factual details.

2) Procedure

My first task was to review the monitoring procedure to be adopted. This appeared to be comprehensive, well designed and generally satisfactory. I suggested, however, that special precautions should be taken to prevent the analysts of the blood-samples from seeing the breath results; this was not for lack of confidence in their objectivity, but simply to follow a type of so-called "blind" procedure such as is commonly used in many clinical investigations to avoid any trace of bias. I also asked that there should be a review of progress after one month, at which I should be present. Both these proposals were accepted, although the former entailed considerable additional administrative work for the Central Research Establishment. I was also present at a review after 4 months.

An additional suggestion, that I warmly supported, was to ask a number of those subjects in the study who following their breath test were opting for a blood or urine sample, to provide in addition, and on an entirely voluntary basis, a second breath test. This was so that there would be a substantial number of tests done close together in time, for more accurate comparison of blood or urine with breath. Despite the problems of implementation that this presented for the police forces concerned, a very valuable body of data was obtained. The cooperation of the subjects and of those forces who were able to participate in this extension of the study is much appreciated. Table A2 in the report shows that they were distributed widely over the country, and the subjects they tested should not be unrepresentative of the general population.

3) The relative status of blood, urine and breath tests

Before commenting on the Report, it is worth giving a brief description of the three methods of test. It appears sometimes to be supposed that the blood-test provides an estimate of what one may call the "alcohol load" in the body, of unique and absolute exactitude. In fact blood, urine and breath samples are all similar in principle. In the words of the Consultative Document,(1) "both blood alcohol concentrations and breath alcohol concentrations are quantifiable substitutes for what is itself not directly quantifiable, namely the impairment of a person's ability to drive safely". Each is simply one type of sample from the body and each is liable to sampling variation as well as analytic error. Sampling variation can arise, both as a result of some difficulty in the procedure, and because of individual physiological variations at the sampling point, for instance in arm blood flow or lung function.

For blood, the sample is normally taken from a vein in the arm, the blood having just passed through the tissues of the arm. Although the sample is taken neither from arterial blood nor near the brain, yet it can be taken as representative of what the brain has been exposed to, because, once the phases of alcohol absorption and distribution are over, alcohol is relatively uniformly distributed throughout the body.

With the breath test, by contrast, the sample consists of lung air that has been exposed to mixed blood from all over the body (including the brain); and this sampling takes place at a point in the circulation just before the blood is recirculated (as arterial blood) to the brain and the rest of the body.

A urine sample provides an estimate of the alcohol in the blood that has passed through the kidneys since the bladder was last emptied. Its usefulness also relies on the relative uniformity of distribution in the body after absorption and tissue uptake is complete.

Blood and urine have the advantage that a single sample provides material for a number of analyses at leisure. The analysis can be made as detailed as desired; but analysis takes days or weeks since the sample must be sent away to a laboratory. The concentration of alcohol in the sample is relatively resistant to variation in the physiological conditions at the time of sampling. A breath sample, by present methods, yields only a single analysis whose specificity is limited, and is more susceptible to physiological variation; but the result is obtained rapidly, and another sample can be easily obtained. With blood, reliance is normally placed on a single blood sample subjected to repeated analyses. In a good laboratory, these should agree within a few per cent.

In the light of these considerations it is not surprising that blood alcohol values have tended to be regarded as the most reliable indicators of "alcohol load". But one may note that blood sampling is not free from error and that one result of the ease of breath sampling is that there is considerably more information on the consistency of analysis of replicate samples of breath than of replicate samples of blood. When breath values come to be compared with those in blood or urine, it is not accurate to regard any disparity between them as necessarily and exclusively due to an error in the breath analysis.

It also follows that the term "blood-breath ratio", which historically has the connotations of a precise physicochemical constant, is better replaced by a more empirical term, such as "apparent breath ratio" or "blood-breath factor", as has been done in the Report. The same applies to the urine-breath factor.

Even if none of the methods of sampling yield an estimate of the alcohol load of absolute precision, it is still the case that, if the procedures are satisfactory, then on average the different methods should be consistent with each other. The study provided a valuable opportunity to test particularly whether the blood-breath factor (2300) used in the legislation to set equivalent breath and blood values (35μg in breath as equivalent to 80 mg in blood) was in fact appropriate.

4) **Blood-breath comparisons with nearly simultaneous samples**

A central question has been the reliability of breath sampling compared to blood sampling, and the risk of injustice to the defendant through the use of breath tests for evidential purpose. The study with second voluntary breath tests has proved of particular value, because for a substantial number of cases the interval between the samples was short enough to render negligible the effects of one variable, alcohol elimination. The data so obtained on the blood-breath factor, shown in Table A6, may conveniently be used, indeed, to illustrate the working of the legislation in practice.

Let us first suppose that an Intoximeter test has yielded a breath result of 40μg/100ml., which is at the lower limit for prosecution. The blood value associated with this will vary between individuals, and the data in Table A6 allow one to assess the range of that variation. The commonest blood-breath factor was in the range 2300–2400; so the commonest blood values would be expected in the bracket 92–96mg% (40 × 2300–40 × 2400μg%); and 99.5% of the subjects (those with a blood-breath factor of 2000 or higher) would have a blood level of 80mg% or higher. By interpolation one may calculate from Table A6 that for about 1 in 10 subjects the blood test would give a result below 87mg/100 ml., the lower blood limit for prosecution after certification (see below). It is for such cases that the statutory option was shaped.

In contrast, one may take the case when a breath test has yielded a result of 35μg%. Here the commonest blood value would lie in the range 81–84mg%. Over 50% of subjects (i.e. 100–48.4%) would have blood levels over 84mg/100ml; and about 1 in 5 would be over 91mg/100ml. If breath testing had not been introduced, this last group would have been liable to conviction.

A third example is when the breath sample has yielded a result of 39μg/100ml, just below the level for prosecution. One can estimate from Table A6 that over 80% of the subjects would have blood values of 87μg/100ml or higher.

Finally, one may consider the case where the breath test gives a value of 50μg/100ml; the commonest value for the blood is now expected to be 115–120mg/100ml, and the lowest blood value from any subject in the survey would be 95mg/100ml.

From this part of the Survey, therefore, the Intoximeter test appears to

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be working satisfactorily. The Camic test appears similar. The blood-breath factor used in framing the legislation has been confirmed. The allowance of 4μg/100ml over the 35μg/100ml limit in breath, (before prosecution is initiated at 40μg/100ml or above), has fulfilled its purpose of protecting subjects who might unjustly be placed in jeopardy by a low blood-breath factor. This is necessarily done at the expense of allowing some other subjects to pass who would have been liable on blood test alone.

5) **Other blood-breath comparisons**

A useful further body of data is provided when all the remaining second breath tests (669) are considered. Table A7 shows that only in 64 tests was the delay between blood and breath sampling greater than 30 minutes; and Table A8, giving the blood-breath factors, reveals a pattern very close indeed to that of Table A6. The less numerous results for the Camic instrument (Tables A27 and A28) are similar.

Finally one comes to the main body of ordinary results, where a breath sample was followed by a blood test at an interval that may be over 2 hours (see Table A9) due, for instance, to difficulty in obtaining a police surgeon. During this interval, a significant degree of alcohol elimination may take place, and this complicates the comparison between blood and breath. It was clearly not practicable to study every case individually. Instead a series of criteria were worked out that would allow computer identification of those cases where question as to the agreement between breath and blood results could reasonably arise. Such cases were then subjected to detailed study.

The result of this careful analysis was that of cases involving blood tests 36 were picked out as for study. Of these there were only 11 out of the overall total of 9976 for which no cause could be more or less positively identified, such as, for instance, the effect of alcohol elimination, or glue sniffing. Even in these cases, inaccuracy by the Intoximeter is only one of a number of possible explanations.

The urine results may be briefly mentioned here. By a similar analysis, there were 10 cases out of a total of 572 where there was a measure of disagreement between breath and urine results that had no obvious explanation.

Taking all the evidence into account, one must conclude that the Intoximeter and the Camic test procedures have functioned acceptably as regards the measurement of alcohol load, in the sense of not placing any subject unjustly in jeopardy.

6) **The acetone detector in the Intoximeter**

The performance of the Intoximeter is less satisfactory as reguards its device for detecting acetone. This substance may appear in blood and breath in severe diabetes and in starvation. In the Intoximeter, but not in the Camic, it may be confused with alcohol. Thus if a subject has acetone in the breath, and if no correction is made, too high a breath alcohol reading would be recorded. The Intoximeter therefore carries special devices intended to estimate the concentration of acetone in the breath and then to make an appropriate deduction from the alcohol reading before print-out.

The Report includes a particularly valuable special investigation, in which the Forensic Service measured the acetone directly in nearly 5000 blood samples, including 2920 cases for which there was a valid Intoximeter breath test. This provides, in Section A4.4.1, a range of evidence both that the detector is quite commonly giving an overestimate of the acetone in the breath, and that it is variable in its reliability from one instrument to another. It is also clear that this defect has been leading, not to injustice to a defendant, but to an underestimate of the alcohol load in a significant number of cases. The figures in Tables A19 and 20 suggest a detectable distortion in around 10–15% of cases, and serious distortion in about 3%. For example, in the group where there was a "large" acetone signal, the outcome could be the association of a breath reading below the limit of 39μg/100ml with a blood alcohol around 115mg/100ml, well above the blood prosecution limit.

The Camic instrument, operating with a different system, is free of this defect.

This aspect of the Intoximeter requires remedy, if the legislation is to be respected. It is not a question of a miscarriage of justice to a defendant, but of the public interest.

7) Other interfering substances

Acetone is just one example of the class of "interfering substances", i.e. substances other than alcohol that might appear in the breath, be detected as alcohol, and (if not separately measured) cause the Intoximeter or Camic to give a false reading. It might be thought that there could be an indefinite number of such substances, with a correspondingly indefinite scope for error by these instruments. In particular, strongly smelling or tasting substances have often been suggested as liable to give false positives.

The range of possibilities, however, is quite limited. To reach the deep air of the lungs, a substance must first be administered by some route from which it can be absorbed into the blood; only from the blood can it volatilise into deep lung air. So the substance will not be restricted to the lungs. The whole body will be exposed to it and to any pharmacological action it possesses. Then it must also be quite volatile, so as to be present in sufficient quantity in the breath to be measured. Finally, all this must take place without incapacitating the subject. The properties required conflict to some extent, and the range of substances with the required absorbability, volatility and general innocuousness is restricted. Mere taste or smell is a poor guide. Suitable substances can only be of a quite low molecular weight, and most substances of the volatility required are not inactive, but are in the nature of anaesthetics.

Turning to the results of the Survey, first one may note that had there been a common source of such interference, it would show itself, inter alia, in a substantial group of anomalously low blood-breath factors. But Table A6, discussed above, shows little evidence of this; indeed the main "outliers" are in the other direction. Secondly, the cases thrown up for special study, listed in Table A11, did indeed include substances which are in fact anaesthetics, namely "glues", butane and petrol. There was also one quite remarkable case (L2/05) which is hard to understand medically; but it still conforms to the general rule that interference requires a substance of relatively low molecular weight. Incidentally, one might expect, sooner or later, that a hosptial patient with a residue of volatile anaesthetic will occur in this context.

The general position appears to be, therefore, that interfering substances can occur, but that they are too limited in number to throw doubt on the general validity of the breath test. But even if there is no reason to fear the existence of a large number of interfering substances "hitherto unknown to science", it remains possible that unrecognised causes of such interference exist. The question then arises as to how far this justifies the continuance of the extended "blood option".

8) Blow differences

A criticism of the Intoximeter has been that it is intrinsically unreliable, as shown by large differences between the two "blows" in a breath test. As explained at the start of this foreword, some degree of variation between successive samples of any kind is to be expected.

Table A21 gives an analysis, for 32007 subjects, of the blow differences obtained in the Survey. In over a half, the difference was not above 2μg/100ml, and in 87.4% it was not above 5μg/100ml. In about 0.2% it was over 20μg/100ml. Since the lower of the two values is used rather than the average, the existence of a difference, if present, favours the defendant. The main importance of the blow difference, therefore, is whether it is so wide as to cast doubt on the instrument altogether; but the extent of congruity recorded in the Table does not support this. Further, as the Report explains, malfunction of the acetone detector, may well account for some of the larger blow differences. Nevertheless, to allow the blood option when the blow difference exceeds some value such as 20μg/100ml would be a sensible practice, to make sure the interests of the defendant were protected.

9) **Rates of alcohol elimination**

In past comparisons of breath and blood alcohol, the blood sample has normally been taken some time after the breath test, when some alcohol elimination will have occurred. To compare breath and blood results fairly, a common procedure has therefore been that of "calculating back", in order to estimate what the blood alcohol value would have been when the breath sample was being taken. To do this an alcohol elimination rate of 15–20mg% per hour in blood has been used. The series of tests in the present Survey, in which two separate breath tests were conducted, gave a unique opportunity to obtain fuller information.

Table A15 gives the results. They confirm past experience; the modal value obtained, 8–9μg/100ml per hour, corresponds to a value for blood of 18–21mg/100ml per hour. Particularly useful, however, is the evidence on the range of elimination rates. Information of this type has usually come from volunteer subjects in laboratory practice. But here the cases are drawn from a much more varied section of the population. The significant finding is that as many as 5% of the group, even after careful review, appear to have elimination rates of 14μg/100ml (32mg/100ml in blood) per hour and higher. These high elimination rates may be a significant fact about biochemical mechanisms in the alcoholic, as well as contributing to the explanation of some of the anomalous cases discussed earlier.

10) **The operation of the instruments**

Although I have not seen it formally articulated, I have gained the impression of a certain scepticism in some quarters over the likelihood that measurements of a laboratory type can be made satisfactorily in a police station by police personnel. I have personally found no evidence justifying the adoption of this attitude. Indeed, from my own experience in the training of technicians and students in laboratory practice, I would expect that a police training would be very satisfactory for such work, in which a carefully prescribed procedure must be meticulously followed. Possibly an archaic image of the modern policeman has been in play.

11) **The general question of the allowances made to avoid unjust conviction**

As the breath test procedure, and the data provided by the Survey, were reviewed, one rather general question emerged. At various points in the procedure, allowances are made to avoid possible injustice to a defendant. Each particular allowance considered in isolation, appears justified. But if one considers their nature, some doubt arises about their all being applied at the same time.

First, there is the deduction of 6% (or 6mg) from the measured blood analysis, to give a "certificated" value. This originated in the recognition of possible error in the analysis. While in scientific work the observed result (or the mean of several observed results) is taken as the most reliable value, here it was felt that the defendant should be given the benefit of the doubt up to quite an unlikely chance variation in the precision of the analysis. The deduction amounts to making allowance for an analysis with an error, happening to be adverse to the defendant, that would occur less than once in 100 analyses. Second, the 4μg/100ml allowance over the 35μg/100ml breath limit, before prosecution is initiated, has a similar origin, in the physiological variations in blood-breath factor. Third, is the use of the lower result of two "blows" in the breath test rather than the average. Finally, the original choice of 80mg/100ml as the limit for blood alcohol made allowance for the varying susceptibility of different individuals to the effect of alcohol on driving competence.

It is not possible in general to measure how much of a worst case is being assumed with each of these allowances. But, to clarify one's ideas, if one supposes that for each allowance the defendant is given the benefit of a 1 in 100 chance, then for three such allowances the overall assumption is of these three chances multiplied together, i.e. an adverse chance of 1 in 1000,000. To protect against 1 such case in a million, a significant proportion of cases that would have been justly convicted are allowed to pass.

The problem is not an easy one. It may well not be possible to quantitate the various risks involved. More generally, at one extreme, no one would wish that every just conviction was achieved regardless of the number of unjust convictions. Equally, no one contemplating the traffic accident figures would wish that no convictions occurred at all, which would be the only way absolutely to guarantee no unjust convictions. It is a truism that some balance between these extremes is required.

It is worth noting, however, that in achieving that balance, the severity of the penalty enters as a factor. If the penalty is especially severe, then the risk of unjust conviction must be the more rigorously avoided. The result is that, while those convicted may indeed suffer condign punishment, the allowances made to avoid injustice allow an appreciable number of offenders to pass unpunished. If the punishment is less severe, then while no one would wish conviction to be other than properly based, yet allowances of the type discussed could well be made less liberally, so that fewer true offenders escape entirely. An alternative to revising the allowances, for each of which there are good arguments, would be to lower the blood and breath limits.

It is thus possible that a better control of drunken driving could be achieved by a different "trade-off" between the severity of penalty and the procedure used. The fact that impairment of driving by alcohol is a "graded" rather than a "threshold" phenomenon makes such an adjustment of the allowances more acceptable. For suppose that a defendant in fact has an alcohol load a little below some prescribed limit, and yet is mistakenly convicted; the graded nature of the effect of alcohol will mean that even below the limit his driving was nevertheless impaired. For an approach to this kind, the present Survey presents much of the type of data needed.

12) Conclusions

1) The procedure adopted in the Survey appears to have been comprehensive, well-designed and generally satisfactory. Valuable additions have been the series of second breath tests, and the special analyses of blood

acetone. The Survey also provides valuable insights into the implications of the current legislation.

2) In the light of the evidence of the Survey, it appears that for providing a quick, replicable measure of alcohol load, the Intoximeter and Camic test procedures are acceptable, in the sense of not placing any subject unjustly in jeopardy. Compared to blood testing they offer the advantage of relative cheapness, and they allow the subject of the test to know promptly whether he or she is liable to prosecution.

3) The Intoximeter is unsatisfactory as regards its acetone detector. It is liable to give an erroneous signal of the presence of acetone, that can in addition lead to an underestimate of the breath alcohol. This is against the public interest. The Camic instrument does not suffer from this defect.

4) The variability of blood-breath factor between individuals justifies the allowance of 4μg/100ml over the 35μg/100ml limit, and the option of giving a blood sample for a suitable range above 40μg/100ml.

5) No evidence was found of the frequent occurrence of interfering substances in breath tests, and they are in any case unlikely. But the possibility of rare instances exists.

6) The occurrence of large blow differences is not sufficiently frequent to cast doubt on the breath test, and with the Intoximeter is probably due in part to malfunction of the acetone detector. To allow a blood test if the blow difference exceeds some suitable limit is reasonable.

7) There is a case for allowing the present non-statutory blood option, for breath test results above 50μg/100ml, to continue indefinitely. On the one hand, it would make little difference to the outcome of most cases, since the net effect of the whole breath test procedure is that, relative to a blood test, it must almost always yield the lower value. The blood test also costs more than the breath test, and prolongs the proceedings. But on the other hand, there are circumstances, such as a large blow difference, or uncommon cases of interfering substances, where a blood test would be generally advantageous. It would also simplify procedure in some respects, and provide a "longstop" for the highly anomalous case. Once the public appreciates that opting for a blood test is generally very unlikely to do more than incur delay and expense, the scale of blood-sampling should not be large.

8) The information about urine tests is more limited. But similar conclusions to those with blood tests seem justified.

9) A valuable feature of the Survey is the new information, over a much wider section of the population than hitherto, of the range of rates of alcohol elimination. This may be providing new data on alcoholism, as well as accounting for some anomalies.

10) No reason was found for lack of confidence in the competence and skill of those involved in the breath-testing procedures.

11) After reviewing the allowances made at different points in the procedure to minimise the risk of unjust conviction, the question arises as to whether, in the measures so far taken to reduce drunken driving, the best "trade-off" between severity of penalty, risk of unjust conviction, and risk of true offenders passing without penalty, has yet been achieved.

REFERENCE

1. Consultative Document on Drinking and Driving. Department of Transport, 1979.

Preface

This report has been prepared as a consequence of a decision by Her Majesty's Government to monitor the performance of the evidential breath testing instruments introduced under the Transport Act 1981. To appreciate fully some of the information contained within this report a knowledge of alcohol metabolism and blood and breath alcohol analysis is required. To help cater for the wide readership envisaged, the report consists of two main parts. The first part contains a brief summary of the results and conclusions and is intended for the non-scientist. The second part (Appendix) contains more scientific detail and is intended for those with a knowledge of the subject.

Summary

Two types of instrument, the Camic Breath Analyser and the Lion Intoximeter 3000 were introduced as evidential breath testing instruments in May 1983. Under the Transport Act 1981 the statutory breath alcohol limit was set at 35μg/100ml, but to allow for measurement variations the effective prosecution limit was set at 40μg/100ml. In addition an option range was introduced which permitted drivers having a breath alcohol result between 40 and 50μg/100ml to elect to supply a specimen of blood or urine to replace the breath test (the statutory option range). Shortly after their introduction concern was expressed about the performance of these instruments and in particular that of the Lion Intoximeter 3000. It was suggested that the instruments were over-estimating the alcohol concentration in breath, that there were problems with the breath sampling system and that the acetone detector (in the Intoximeter) was unreliable. In March 1984 the Home Secretary announced a 6 month survey period during which the option range was extended on a non-statutory basis permitting anyone who wanted to supply a blood or urine sample in addition to a breath sample to do so. The Forensic Science Service was to monitor the results obtained during this period and this report details these results. A total of 41565 cases were examined of which 12715 consisted of a blood or urine result together with one, or two breath test results. Sixty-nine percent of subjects with a breath test result in the statutory option range (40–50μg/100ml) elected to provide a laboratory specimen together with 37% of subjects with a breath test result above this range.

Intoximeter
There were 12066 cases where the subject took a breath test and provided a laboratory specimen. Out of this total, there were 21 cases (11 blood and 10 urine) where the differences between the results obtained from the breath and the blood (or urine) specimens could not be explained. However in all these cases there was a significant time interval between provision of the breath and laboratory specimens and this introduces an element of uncertainty into the interpretation of these results. Additionally, there were 10 cases where breath samples were supplied by subjects who had indulged in solvent/gas abuse and these gave higher readings on the Intoximeter than would be expected from the subject's blood or urine alcohol concentration.

In approximately 10% of breath tests on the Intoximeter the presence of acetone was indicated, but analysis of a considerable number of laboratory samples showed that none contained sufficient acetone to produce a genuine acetone response. There is no evidence that drivers have been wrongfully prosecuted because of this fault; the converse is true since whenever acetone is indicated (due to its presence or a fault) a correction is applied which reduces the breath alcohol concentration indicated. This has probably resulted in guilty drivers escaping prosecution. The acetone detector on this instrument is clearly unsatisfactory and requires attention.

Approximately 3% of subjects were unable to fulfil the requirement of the breath test and therefore this aspect of performance does not appear to be a widespread problem. In 1.6% of cases the difference between the two breath samples in each breath test was more than 20%. A significant number of cases showing these large differences also showed an acetone indication on the Intoximeter which suggests that there may be a link between the large differences and the malfunctioning of the acetone detector.

Camic

There were 649 cases where a laboratory specimen was supplied in addition to a breath sample. In only one case the difference between the results from the laboratory analysis and the breath test could not be obviously explained, but, there was a significant time interval between provision of the breath and laboratory specimens. In 1.7% of the cases the difference between the two breath sample results was 20% or more.

Conclusions

Intoximeter

1. There is good evidence that the Lion Intoximeter 3000 is not over-estimating the concentration of alcohol in the breath except in the presence of some volatile chemicals.
2. The Intoximeter may respond to solvents and other volatile materials if present in sufficient quantities in the breath and give erroneous readings. Such readings are encountered with solvent abusers.
3. Of the 4834 laboratory samples analysed for acetone none were found to contain sufficient to generate a genuine acetone indication on the Intoximeter. No relationship was found between the blood acetone concentration and the acetone indications on the Intoximeter.
4. There is no evidence that the malfunctioning of the acetone detector has caused subjects to be wrongfully prosecuted.
5. In a few cases (1.6%) there were differences of over 20% between the individual breath sample results. There is evidence that some of these large differences are associated with the performance of the acetone detector. The suggestion of Emerson et al.(1) that a blood sample should be taken if this difference exceeds a prescribed amount has much to commend it.

Camic

1. There were too few cases where the breath and blood specimens were taken simultaneously to assess reliably the performance of this instrument. Nevertheless there is no evidence from the data obtained that the Camic Breath Analyser is over-estimating the amount of alcohol in the breath. No cases involving solvent abuse were encountered.
2. In a few cases (1.7%) there were differences between the individual breath samples of 20% or more.

1. Introduction

History The Road Safety Act 1967 introduced for the first time in Great Britain, the concept of a statutory limit to the amount of alcohol legally permitted in a driver's body and was an attempt to stem the rise in the number of alcohol related road accidents. Under this Act the maximum legal limit in blood was set at 80 milligrammes of alcohol per 100 millilitres of blood (mg/100ml) and at 107mg/100ml in urine. The motorist was required to take a preliminary screening roadside breath test and if this proved positive the subject was arrested and taken to a police station. The motorist was given the choice of supplying either a specimen of blood or urine, the former being taken by a medical practitioner. The specimen was divided into two parts, one being sent by the police to a forensic science laboratory and the other was offered to the motorist so that he could obtain his own independent analysis.

Although the statutory limit was initially very effective in reducing alcohol related traffic accidents, the effect diminished until by 1974 the numbers of alcohol related deaths exceeded the pre 1967 levels. As a result of concern at the worsening situation a committee was appointed by the Minister of Transport in 1974 to "review the operation of the law relating to drinking and driving and to make recommendations". The Committee, under the chairmanship of Mr (now His Honour Judge) Frank Blennerhasset QC reported in April 1976 and one of the recommendations made was that breath analysis should replace blood analysis for forensic purposes.

Evaluation of Instruments As a result of this recommendation a study of evidential breath alcohol measuring equipment was undertaken by scientists at the Central Research Establishment, Home Office Forensic Science Service (CRE). A number of commercially available instruments were evaluated in the laboratory and in two field trials(1, 2) instruments were placed in selected police stations. Motorists who had been arrested for alleged drink driving offences were invited to supply breath specimens for analysis by the instruments after they had satisfied the legal requirements in relation to the provision of blood or urine. Results of the blood (or urine) and breath analyses were collected and used to assess various aspects of instrument performance. The first field trial, (1) which assessed several instruments, confirmed the viability of evidential breath testing and indicated that a blood alcohol concentration of 80mg/100ml was equivalent to 35 micrograms of alcohol per 100 millilitres of breath (μg/100ml), although there were measurable variations between subjects. The second field trial ran from October 1981 to February 1982 and two instruments, the Lion Intoximeter 3000 (Intoximeter) and the Camic Breath Analyser (Camic), were found to be suitable for evidential use. These were subsequently approved by the Home Secretary for use under the Transport Act 1981. The second trial also confirmed the relationship between blood and breath alcohol and the variability between subjects found during the first trial.

Transport Act 1981 During the various consultations which preceded the introduction of the Act, two safeguards were thought necessary. The first was that the lower of two breath sample results should be used for prosecution purposes and this requirement was subsequently written into the Act.(3) Secondly, it was recommended to the police(4) that there should be no prosecution below 40μg/100ml, although the legal limit in breath would be 35μg/100ml. This recommendation was to allow for the variation which is intrinsic in any measurement.

Both field and laboratory trials showed that the relationship between the blood and breath alcohol concentrations varied between individuals and that it was very unlikely that anyone having a blood alcohol concentration below the legal limit would have a breath alcohol concentration greater than 50μg/100ml.(5) Although under the proposed legislation, an offence would be committed if a subject had a breath alcohol concentration above the prosecution limit of 40μg/100ml, it was thought desirable to introduce an option range enabling subjects just over this limit to elect to supply a specimen of blood or urine. This would a) allow for those subjects who had proportionately more alcohol in their breath than would normally be expected and b) provide a sample for independent analysis if the subject so wished. The upper limit of the option range was fixed at 50μg/100ml and in cases where a laboratory specimen was taken from subjects within this range the result obtained from such a specimen replaced the breath alcohol concentration for prosecution purposes.

Because of the principle on which the instruments work it was anticipated during their initial assessment that some substances might interfere with the accurate estimation of breath alcohol. During the evaluations both the manufacturers and Home Office staff carried out tests to assess the effect of various substances which one might expect to find in breath. These included various mouthwashes, sweets and tobacco smoke. At that time the incidence of solvent abuse (eg glue sniffing) had not reached its current level and appeared to be confined to those below minimum driving age. However, as a precautionary measure the Home Office informed the Traffic Committee of the Association of Chief Police Officers on 10 June 1983 that where "glue sniffing" was suspected the instrument should not be used and the subject should be required to give a blood sample. Therefore it was known at the time the instruments were first introduced that solvent abuse could give rise to erroneous readings on the instruments.

The two types of approved instruments were introduced on 6 May 1983. Both require minimal operator involvement and for each breath test the instruments follow the same automatic operating sequence ie.

a) Blank (atmospheric sample)
b) First calibration check using vapour from external standard solution
c) Blank (atmospheric sample)
d) First breath sample
e) Blank (atmospheric sample)
f) Second breath sample
g) Blank (atmospheric sample)
h) Second calibration check using vapour from external standard solution.

The operating sequence shows that in each complete breath test 2 separate breath samples are analysed. Before each stage of the sequence the instrument sample chamber is automatically flushed with air and a check made that a reading of zero is obtained with an atmospheric sample. If the first calibration check is out of specification the analysis program abandons the above sequence automatically and the instrument cannot be used for the test. If the second calibration check is out of specification then in the case of the Intoximeter a complete record of the tests is printed together with a warning message. In the case of the Camic, if either calibration check is out of specification the test record is not printed.

Both instruments use a detector which works on the principle of the absorption of infra-red radiation by alcohol. Acetone, if present in sufficient quantities, interferes with the measurement of alcohol by the infra-red detector in the Intoximeter and this instrument therefore incorporates a second (semiconductor) detector to estimate the acetone in the breath sample and make the necessary correction. The Camic limits acetone interference by the use of a narrow band-width infra-red filter.

The Problems The majority of instruments introduced in England and Wales in May 1983 were Lion Intoximeters (approx 600) with fewer Camic instruments (approx 50). In the months following their introduction disquiet was expressed about instrument accuracy and performance. Four main areas of concern were identified, namely:

(a) Alleged over-estimation of the concentration of alcohol in breath.
(b) Failure of genuine attempts to provide samples of breath for analysis due to instrument malfunction.
(c) Markedly different results from the two samples of breath constituting a single breath test.
(d) A disproportionately large number of acetone indications on the Intoximeter indicating that the acetone detector was not functioning correctly.

The Survey Period As a result of this concern the Home Secretary announced on 26 March 1984 that in England and Wales there would be a 6-month survey period beginning 16 April 1984 during which instrument performance would be monitored by the Forensic Science Service. During the survey period the existing statutory option, which enabled a motorist to supply a sample for laboratory analysis if the breath test result was 50μg/100ml or below, was extended on a non-statutory basis to all motorists irrespective of breath alcohol concentration. Professor Sir William Paton FRS was appointed to act as an independent scrutineer and was consulted prior to the design and organisation of the survey. Recommendations arising from these discussions were the necessity to take second breath tests as soon as possible after the provision of the laboratory sample and the desirability that the analyst should be unaware of the result of the breath test prior to analysis of the blood or urine sample.

This report summarises the data received during the monitoring period and considers the four areas of concern.

2. Organisation of the Survey

2.1 Initial Considerations

The only feasible method of assessing the performance of the breath testing instruments was to compare the results of breath analysis with those of blood (or urine) analysis. The most valid comparisons are made when the samples are taken simultaneously or within a very short period of time and such samples therefore form the most reliable basis for assessing instrument performance. The theoretical basis for this fact involves a consideration of alcohol absorption, distribution and elimination in the body and will not be discussed in this report.

Experience has shown that samples taken within ten minutes may be regarded as 'simultaneous' for comparative purposes. Because there is almost always a delay between the provision of a breath sample and the subsequent availability of a doctor, blood and breath samples are rarely taken within ten minutes of each other and it was for this reason that some subjects were invited to take a second breath test during the survey period.

The provision of this second breath test, for which there was no legal requirement, introduced problems for the police in that it could not be allowed to interfere with the legal procedures which had to be rigorously followed. This required a further set of police procedures in addition to those relating to the non-statutory option and although there were problems associated with training a large number of police officers in a very short time, nine police forces agreed to seek voluntary provision of a second breath test, although not all did so for the full survey period.

2.2 Classification of cases

Cases have been divided into three groups. *Group A* consists of cases in which a breath test (first or second) was taken within ten minutes of a laboratory specimen ('simultaneous' samples) and provides a useful core of over 800 cases on which the best comparisons can be made. *Group B* consists of cases in which second breath tests had been taken and the time interval between both breath tests and the laboratory specimen exceeded 10 minutes but was generally less than 20 minutes. This second group of results, whilst not as useful as the first, was a group within which reasonable comparisons could be made. The final group *(Group C)* consists of the bulk of the cases where a single breath test was followed by the provision of a laboratory specimen more than 10 minutes later (typically 30–45 minutes).

2.3 Cases Involving Urine

In the field trials(1,2) all the urine results were disregarded. There is no fundamental relationship between breath alcohol and urine alcohol similar to that existing between breath alcohol and blood alcohol and all comparisons between breath and urine involve an intermediate calculated blood alcohol concentration. A similar approach would have been justified in this survey but in order to extract the maximum amount of information from the survey data, it was decided to include all urine results. However it must be emphasised that the urine cases provide a much less reliable database than the blood cases on which to base conclusions.

2.4 **Implementation of the Survey**

It was necessary to collect data from 43 police forces in England and Wales and from 7 forensic science laboratories.

Following apprehension, the subject was required to provide two samples of breath at a police station. If the lower of the two results was 40μg/100ml or above and the subject did not wish to supply a laboratory specimen for analysis, a copy of the print-out was sent to the Breath Alcohol Monitoring Unit (BAMU) at CRE.

If the subject elected to provide a laboratory specimen this was forwarded to the forensic science laboratory together with a copy of the breath test print-out. These items were received in the reception office at the laboratory and allocated a case number. The print-out was then sealed in an envelope and later sent with a copy of the laboratory certificate of analysis to the BAMU. Thus analysts did not see the breath test print-outs. In instances where a breath test was not taken, a form was completed by the police officer stating the reason and this was sent via the laboratory to the BAMU with the certificate of analysis.

This procedure prevented the rapid investigation of instances where discordant results were obtained, but had the advantage that the breath and blood/urine results were received together and it was therefore unnecessary to store subject names on computer. Since breath test results alone are of value in assessing some aspects of instrument performance, every available result was added to the data collection irrespective of whether or not a laboratory specimen was provided.

3. Validity of Survey

Every effort was made to ensure that all cases were included in the survey, and there is good evidence that a very high proportion of cases involving the forensic science laboratories have been received. It is not possible to be so sure about cases involving only breath testing. Some instruments appear to have been little used, although in the case of the Camic this may be explained by the fact that some operators failed to write the instrument number on the print-out and a considerable number of results from unidentified Camic instruments have been included in the survey. (The Lion Intoximeter 3000 automatically prints the instrument serial number on every print-out).

On receipt at the BAMU all data were examined prior to data processing. All data were processed twice using normal validation procedures and magnetic tapes received from data processing were checked by the computer to ensure that data were sensible and lay between pre-defined limits. Any errors were rectified at this stage. Finally a portion of each batch was compared against the computer record to check for errors from any source.

It is inevitable in a survey such as this that some data may be duplicated. A common problem was that breath test print-outs from subjects who had also supplied a laboratory specimen were sent to both the forensic science laboratory and to the BAMU by the police, resulting in a double entry on the computer. Check programs were devised to eliminate such duplications to ensure no artificial inflation of the survey.

4. Total Numbers Exercising Option to give a Laboratory Specimen

4.1 Statutory Option Range (40–50μg/100ml)

There were 6439 subjects whose lower breath sample result lay in the statutory option range (40–50μg/100ml). Of these, 4442 (69%) elected to give a specimen for laboratory analysis. Table 1 indicates that over 84% of subjects were found to be above the statutory limit at the time the laboratory specimen was taken c.f. 80% found by Isaacs and Hunt.(10) However, because of the time interval between the breath test and provision of the laboratory specimen in some cases this figure should not be taken to imply that in the remaining 16% of cases the instruments were over-estimating the amount of alcohol in the breath. (see later)

Table 1 Options exercised in statutory option range (40–50μg/100ml)

	Total	Certified value above limit	Certified value below limit	Percentage of samples above limit
No. supplying blood sample	4316	3649	667	84.5
No. supplying urine sample	126	95	31	75.4
TOTAL	**4442**	**3744**	**698**	**84.2**

4.2 Non-statutory Option Range

There were 23088 subjects whose breath test result was above the statutory option range (51μg/100ml or over). Of these 8561 (37.1%) elected to supply a specimen for laboratory analysis and these results are given in Table 2. Overall 99.6% of subjects had a certified blood or urine alcohol concentration above the statutory limit. The 31 cases constituting the remaining 0.4% are dealt with in Sections 5 and 6.

Table 2 Options exercised in non-statutory option range (51μg/100ml or over)

	Total	Certified value above limit	Certified value below limit	Percentage of samples above limit
No. supplying blood sample	8043	8022	21	99.7
No. supplying urine sample	518	508	10	98.1
TOTAL	**8561**	**8530**	**31**	**99.6**

5. Lion Intoximeter 3000

A total of 12066 subjects supplied both a valid breath test on the Intoximeter and a laboratory specimen. Of these, 1388 also agreed to provide a second breath test following provision of the laboratory specimen. Table 3 shows the number of blood and urine samples obtained in the survey.

Table 3 Lion Intoximeter 3000 cases which included a laboratory sample

	Time interval between breath and blood or urine samples			
	One or both under 10 mins	All over 10 mins	Not known	Total No. of Cases
Blood Cases				
Single breath test	181	9976	30	10187
Dual breath test	636	670	1	1307
Total (Blood)	817	10646	31	11494
Urine Cases				
Single breath test	3	478	10	491
Dual breath test	41	40	0	81
Total (Urine)	44	518	10	572
GRAND TOTAL	**861**	**11164**	**41**	**12066**

5.1 Comparison of blood and breath results

A set of criteria was formulated to help identify cases where an apparent disparity existed between the breath test result and the result of laboratory analysis. These criteria are listed in the Appendix. Cases which satisfied any of these criteria were classified as 'possibly anomalous' and were examined in detail. If no explanation for the disparity was found they were reclassified as 'anomalous'.

There were 817 Group A cases (see Section 2.2) in which the blood (or urine) results can be compared directly with the breath test result. There were no anomalous cases in this group. The blood and breath results confirmed that a breath alcohol concentration of 35μg/100ml is equivalent to a blood alcohol concentration of 80mg/100ml.

Of the 670 Group B cases, there were no anomalous results. Two subjects were found to be solvent/gas abusers and this explained the discrepancy between the results.

There were 11 cases (0.11%) out of 9976 Group C cases where the reasons for the differences between the breath and blood results were not apparent. A number of possible explanations exist for these discrepancies, including instrument malfunction, and these possibilities are discussed in the Appendix. One of the subjects in these 11 cases was found to have unusual organic substances in his blood, possibly as a result of a metabolic disorder resulting from a long history of gas abuse.

Therefore out of the 11463 cases where a blood and breath sample had been taken there were only 11 anomalous cases and they were amongst the group of non-simultaneous samples.

5.2 Comparison of urine and breath results

Of the 44 Group A cases none were anomalous.

Of the 40 Group B cases two were anomalous. In one anomalous case the difference between the first and second breath test results suggested an extremely high elimination rate of alcohol from the breath. This could be a genuine result but may also be due to an interfering substance in the breath or a faulty instrument. There was no evidence of solvent abuse from the information available.

Of the 478 Group C cases 8 were anomalous.

Therefore from a total of 562 cases there were 10 (1.78%) that were anomalous, a higher percentage than that observed in the cases involving blood specimens. The higher relative frequency of anomalous results associated with urine specimens is more likely to be associated with the uncertainty in relating the urine alcohol result to the amount of alcohol present in the body, than with any fault in the Intoximeters.

5.3 The Acetone Detector

A large number of acetone indications at all levels ('TRACE', 'MODERATE' and 'LARGE') were recorded in this survey. Overall 10.2% of first breath tests showed an acetone response and there were major variations between the performance of individual instruments. This survey shows that some instruments are more liable to give acetone indications than others.

During the survey 4834 laboratory specimens were analysed for acetone in addition to alcohol, including those from all subjects showing 'MODERATE' or 'LARGE' acetone on the Intoximeter. (The laboratories were informed by BAMU of the cases involved.) The data obtained show that there was insufficient acetone in any of the blood samples analysed to produce a genuine acetone indication on the Intoximeter. It is therefore highly probable that all acetone indications on the Intoximeter in this survey have been a result of a malfunction of the acetone detector.

The question arises as to whether these false acetone indications could have resulted in any wrongful convictions.

The instrument incorporates an infra-red detector, which is sensitive to both alcohol and acetone, and a solid state detector which is also sensitive to both substances but which has an increased sensitivity to acetone. The computer within the instrument is able to use this difference in sensitivity to make the necessary correction so that only the alcohol content of the breath is reported. In a faulty instrument a correction can be made in the absence of acetone resulting in an under-estimation of breath alcohol.

If under-estimation occurs then calculation (in the BAMU) of the breath alcohol concentration from the blood analysis should yield a higher figure than that obtained from the Intoximeter. This was, in fact, found to be the case. It is therefore probable that some drivers having a breath alcohol level just above the legal limit have escaped prosecution because of the malfunctioning acetone detectors. Although the acetone detector is unsatisfactory and requires attention there is no evidence that it has resulted in wrongful convictions. The problems are discussed further in the Appendix.

5.4 Difference between the two breath samples in each breath test

Concern has been expressed that in some cases there is a marked difference between the results obtained from the two breath samples provided in a single breath test. However, it is known that eructation ('belching') can produce an erroneously high figure and that lung capacity and the way in which a subject blows into the instrument can also have a bearing on the final result obtained.

Out of 33395 breath tests in this survey over 50% of the results showed a difference of 2μg/100ml or less and only 89 (0.27%) showed a difference of 20μg/100ml or more. Of these 89, a blood or urine analysis was available in 51 cases and in 26 of these the result corresponded more closely to the higher breath result. In approximately 25% of the 89 cases showing a breath difference of over 20μg/100ml, the presence of acetone was indicated by the instrument. If the breath difference is expressed as a percentage of the lower breath result, the number of cases where this difference exceeded 20% was 543 (1.6%) and approximately one third of these cases are associated with an acetone indication. Therefore there is considerable evidence to suggest that some of the large breath differences recorded may be attributable to the malfunctioning of the acetone detector.

A total of 32007 drivers completed a breath test on the Intoximeter and an additional 929 (2.9%) drivers were unable to provide the two breath samples required. The 929 cases do not include those where a driver has wilfully refused to provide a sample and has been consequently charged with "failing to provide", but do include cases where the subject was reported as being "too drunk" to provide a specimen. Thus the inability to provide a sample does not appear to be a widespread problem and there appears to be little difference between the Intoximeter and the Camic in this respect.

6. Camic Breath Analyser

Only 4 Police Forces in England and Wales use the Camic Breath Analyser and therefore there are fewer results available from this instrument than from the Intoximeter.

6.1 Comparison of blood and breath results

Table 4 shows the numbers of results obtained for the Camic instrument.

Table 4 Camic Breath Analyser cases which included a laboratory sample

	Time interval between breath and blood or urine samples			
	One or both under 10 mins	All over 10 mins	Not known	Total No. of Cases
Blood Cases				
Single breath test	14	548	2	564
Dual breath test	14	20	1	35
Total (Blood)	28	568	3	599
Urine Cases				
Single breath test	1	38	1	40
Dual breath test	5	5	0	10
Total (Urine)	6	43	1	50
GRAND TOTALS	**34**	**611**	**4**	**649**

There were 28 Group A cases and 20 Group B cases. There was one case in Group A where the breath test result was higher than would normally be expected from the blood test result but was not abberant enough to be classified as anomalous. The breath test result lay within the statutory option range and it was for such cases that the option was introduced. The 548 Group C cases included one that was anomalous. The breath test result was in the statutory option range and the opportunity for a blood test was available to the subject.

Out of a total of 599 blood to breath comparisons one (0.17%) was classified as anomalous. This is approximately the same percentage as that found with the Intoximeter.

6.2 Comparison of urine and breath results

There were no anomalous cases in this group.

6.3 Acetone Detection

The design of the Camic Breath Analyser is such as to minimise acetone interference and the instrument therefore has no separate acetone detector. The instrument therefore does not indicate when acetone is present and hence this aspect of performance could not be assessed in this survey.

6.4 **Difference between the two breath samples in each breath test**

Over 50% of the 1877 first or second breath tests showed a difference between the results from the two breath samples of 2μg/100ml or less and only 10 showed differences of 20μg/100ml or over. Of these 10 there were 7 cases where a blood sample was taken and 3 showed the blood result to correspond more closely to the lower breath result. A reading of 254μg/100ml was recorded in one case which is particularly high and is a instrument fault.$^{(12)}$

If the breath difference is expressed as a percentage of the lower breath result then there were 33 cases (1.7%) where Camic instruments showed differences of over 20%.

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Appendix

A1 Preliminary considerations

A1.1 Errors in blood and breath analyses

In forensic science laboratories blood and urine specimens are analysed twice initially. If the mean result exceeds the prescribed limit by less than 15% (approx) then at least 4 analyses are carried out. Providing the results are in close agreement (±2% of the mean) a deduction of 6% is made from the mean result if it is above 100mg/100ml. If the mean result is 100mg/100ml or below a fixed amount of 6mg/100ml is deducted. The deduction represents at least 3 standard errors and allows for experimental error. The reduced figure is used on the certificate and hence a sample found to have a mean blood alcohol concentration of 86mg/100ml is reported as containing "not less than 80mg alcohol per 100 millilitres of blood" on the Certificate of Analysis.

The measurement error of the evidential breath testing instruments was considered prior to their introduction and was of fundamental importance in formulating the two safeguards mentioned in the Introduction The 5μg/100ml allowance between the prescribed limit and the prosecution limit allows for measurement error in the breath testing instruments and is analogous to the 6% deduction made in the laboratory. Selecting the lower result from two separate breath samples errs on the side of the subject especially in the case of 'belching'.

The classification of samples taken within 10 minutes of each other as 'simultaneous', derives from a consideration of measurement errors involved in the estimation of both blood and breath alcohol. The time interval was calculated on the basis that it would probably be difficult to discriminate reliably between the blood alcohol concentration of two blood specimens taken 10 minutes apart from someone in the elimination phase.

A1.2 The Statutory Option Range

Both field and laboratory trials showed that a range of apparent blood to breath ratios were observed with the mode at approximately 2300:1. It was also shown(5) that it was unlikely that anyone would have a blood alcohol concentration below the legal limit and a breath alcohol concentration greater than 50μg/100ml. Hence the statutory option range was introduced for subjects who, at the time of testing, had abnormally low apparent blood to breath ratios but the range was limited to cases where the breath alcohol concentration was not greater than 50μg/100ml.

A1.3 Corrections for Non-simultaneous Samples

In the field trials(1, 2) a correction was made to the results to take account of the metabolic elimination of alcohol from the body since one of the objectives of this work was to establish the correct blood to breath ratio to use in subsequent legislation.(3)

The use of time corrections in both of the field trials enabled a more accurate blood to breath ratio to be calculated and was therefore fully justified in that it protected the future interests of subjects taking breath tests. The procedure chosen, although not ideal, was the best that could be arranged given the various legal restraints which existed. There have been criticisms of the use of such time corrections but these criticisms are not universally accepted. However, it is accepted that if the subject has not entered the elimination phase then the use of time corrections is inappropriate.

In the survey reported here the results have *not* been corrected. To avoid disregarding all results where the time interval between provision of the breath and laboratory specimens exceeded 10 minutes (non-simultaneous), an alternative method of assessment was devised. A set of criteria was formulated to identify cases which showed an apparent disparity between the breath and blood or urine results. If no explanation for the disparity was evident, the results were classified as anomalous. In examining the non-simultaneous cases, the rate of elimination from blood (or urine) was calculated making the assumption that the subject was in the elimination phase. The metabolic rate of elimination of alcohol from the body can vary substantially between individuals and wide variations have been recorded in the literature. There is evidence(6) to show that some heavy drinkers can eliminate alcohol from blood at rates in excess of 30 milligrammes per 100 millilitres per hour (30mg/(100ml.h)) and this survey may include subjects in this category. Social or moderate drinkers would be expected to eliminate alcohol at lower rates and a figure commonly quoted for blood is 15mg/(100ml.h). During laboratory trials of the breath testing instruments, the average elimination rate from blood was found to be 19mg/(100ml.h).(7) In this survey it has been assumed that elimination rates of up to 40mg/(100ml.h) may be encountered in a few cases (17.4μg/(100ml.h) from breath).

A1.4 **Blood to Breath Ratios, Apparent Ratios and Factors**

In order to determine the true blood to breath ratio the alcohol in the body must be evenly distributed, the expired air sample analysed must be in equilibrium with the blood and the specimens of blood and breath must be taken simultaneously. In most practical situations one or both of the first two conditions will not be fulfilled and in these situations only the *apparent* blood to breath ratio will be measured.

A ratio derived from samples taken some time apart has no accepted scientific term and is referred to here as a blood to breath *factor*. Such factors are suitable for checking for the occurrence of subjects who may have a breath alcohol concentration result above the statutory option range but a blood alcohol result below the legal limit. Factors have been calculated for all cases where the necessary results have been obtained. Most cases consist of a single breath test followed by provision of a blood sample and in these cases factors progressively fall to zero as the time interval between provision of the samples increases.

Subjects having, simultaneously, breath alcohol concentrations of 51μg/100ml or above, and certified blood alcohol concentrations of 80mg/100ml or less (86mg/100ml or less analysed) would have an apparent blood to breath *ratio* of

$$\frac{86\text{mg}/100\text{ml}}{51\mu\text{g}/100\text{ml}}$$

≃ 1700 or less. All cases in which the blood to breath *factor* fell below 1700 have been examined in detail to establish whether the low value can be explained by the time interval between the breath test and provision of the blood sample.

Similarly with urine cases, subjects having a certified urine alcohol concentration would of 107mg/100ml or less (114mg/100ml or less analysed) would have an apparent urine to breath *ratio* of

$$\frac{114\text{mg}/100\text{ml}}{51\mu\text{g}/100\text{ml}}$$

≃ 2235 or less. [This calculation assumes a blood to urine alcohol ratio of 3:4 as is implicit in the Transport Act]. All cases in which the urine to breath factor fell below 2235 have been examined in detail in a similiar way to those cases involving blood.

A1.5 **Computer requirements**

The Forensic Science Service's Prime 550 (a large minicomputer) was used in this survey. The computer is fitted with 2 megabytes (MB) of memory, 32MB of virtual memory and a total of 500MB of hard disc storage.

For each case there could be up to 35 separate items of information and from these items a further 11 values were calculated. The information was stored in a master text file which occupied only 3.36MB by the use of space compression. With all the ancillary files, program and workspace, the total memory requirement was approximately 50MB. Use was made of a commercial software package(11) to produce some of the tables in this report and the master data file for this package accounted for 6.9MB of memory.

The project occupied the computer for approximately 900 hours of which approximately 93 hours was CPU time.

A2 Summary of Data Collected (Intoximeter and Camic)

A case record was made up of one or more of the following documents:

a) Certificate of Analysis showing the blood or urine alcohol concentration

b) a breath instrument print-out

c) a "failure to supply breath" (FTSB) form showing why a breath specimen had not been obtained.

The case records formed by certain combinations of these documents are shown in Table A1. Case types 2 and 4 include a second breath test and types 8 and 9 consist entirely of cases where the second calibration check was out of specification. The Camic does not normally produce a data print-out if the second calibration check is out of specification and in one case a print-out was obtained because of a machine fault. In another the police officer wrote down the results displayed on the machine and supplied them to the BAMU.

Table A1 shows the total numbers of each case type and Table A2 shows the numbers of case types from individual police forces. Where the sex of the subject could be established from the name on the print-out 95% were male. Of the 41565 records collected 12066 cases included a Certificate of Analysis together with the Intoximeter print-outs. Only 649 cases of this type are available for the Camic.

Where a valid breath test was not obtained a FTSB form should have been completed and the possible reasons are shown in Table A3.

Table A1 indicates that in 8152 cases (19.6%) it was not possible to obtain a valid breath test result and Table A3 gives the reasons why this was so. The number of instances when an operator was not available varied widely between forces and in some an operator was always available.

Failure to provide a breath sample for medical or non-medical reasons accounted for some 12% (988) of the 8152 cases where a valid breath test was not completed. These cases amount to approximately 2.4% of the total survey and therefore the number of people unable to complete a breath test appears small. The figure of 988 does not include cases where a driver has wilfully refused to provide a sample and has been consequently charged for 'failing to provide', but does include cases where the subject was reported as being 'too drunk' to provide a specimen. There appears to be little difference between the Intoximeter and the Camic in the percentage of people being unable to complete a breath test.

To minimise the amount of non-useful information the following types of cases were excluded from the survey.

a) Blood or urine result zero *and* all breath sample results zero.

b) Blood or urine samples which were unsuitable for analysis or for which a certificate was not issued.

c) Cases where the blood or urine result was zero and the breath test result was not available or no breath test completed.

There was a total of 242 cases in these categories.

There were 1446 print-outs received from the police forces where the requirements of the procedure had not been fulfilled, and no laboratory sample was obtained. This data could not be included in the survey and some of the reasons for the test not being completed are given in Table A4. In the majority of cases the reason was not supplied.

A3 Criteria for the Identification of Possibly Anomalous Cases

The four main causes of concern associated with these instruments have been listed earlier and the first, viz. over estimation of the concentration of alcohol in breath, has been examined by comparing the breath test results with the results obtained by analysis of the laboratory specimen. Breath and blood specimens taken 'simultaneously' can be compared directly. Possibly anomalous results amongst the non-simultaneous cases were identified for further investigation using the following set of criteria.

1. Lower result from first breath test over 50μg/100ml, but blood result under 81mg/100ml (certificate).
2. Lower result from first breath test over 50μg/100ml, but urine result under 108mg/100ml (certificate).
3. Lower result from first breath test between 40 and 50μg/100ml, but blood result under 81mg/100ml (certificate).
4. Lower result from first breath test between 40 and 50μg/100ml, but urine result under 108mg/100ml (certificate).
5. Lower result from first breath test between 40 and 50μg/100ml, blood result under 81mg/100ml (certificate) and time difference between the two of 10 minutes or less.
6. Lower result from first test between 40 and 50μg/100ml, urine result under 108mg/100ml (certificate) and time difference between the two of 10 minutes or less.
7. Blood to breath factor less than 1700.
8. Urine to breath factor less than 2235.
9. Blood to breath factor less than 1700 and elimination rate over 40mg/(100ml.h) required.
10. Urine to breath factor less than 2235 and elimination rate over 53mg/(100ml.h) required.
11. Lower result from second breath test over 50μg/100ml, but blood result under 81mg/100ml (certificate).
12. Lower result from second breath test over 50μg/100ml, but urine result under 108mg/100ml (certificate).
13. Lower result from second breath test between 40 and 50μg/100ml, but blood result under 81mg/100ml (certificate).
14. Lower result from second breath test between 40 and 50μg/100ml, but urine result under 108mg/100ml (certificate).
15. Lower result from second breath test between 40 and 50μg/100ml, blood result under 81mg/100ml (certificate) and time difference between the two of 10 minutes or less.
16. Lower result from breath test between 40 and 50μg/100ml, urine result under 108mg/100ml (certificate) and time difference between the two of 10 minutes or less.
17. Blood to second breath factor less than 1700.
18. Urine to second breath factor less than 2235.

The first two criteria are used to assess whether the upper limit of the statutory option range is high enough. With normal biological variations subjects should not have a breath alcohol concentration over 50μg/100ml and a certified blood alcohol concentration of under 81mg/100ml unless the blood specimen is provided a long time after the breath sample.

It is to be expected that a minority of subjects with breath test results in the statutory option range will provide laboratory specimens containing less than the legal limit of alcohol. It was for these subjects that the statutory option range was introduced and such cases are identified by criteria 3 and 4. Because of this statutory right to supply a laboratory sample, cases occurring in this range are not seen as a problem. Valid comparisons can be made if samples are taken simultaneously and any possibly anomalous cases are identified by criteria 5 and 6 (Group A cases).

Criteria 1–6 only select results near the statutory limits but criteria 7 and 8 are used to check the agreement in all cases. A person with an apparent blood to breath ratio of less than 1700 could have a breath alcohol concentration above the statutory option range but a certified blood alcohol result below the legal limit.

The time interval between provision of the breath and laboratory specimens in the possibly anomalous cases identified by criteria 7 and 8 were investigated by calculating the elimination rate required to reconcile the two results. Alcohol is eliminated from the blood by oxidation in the liver and this reduced concentration is reflected in reductions in the breath and urine alcohol concentrations. If it is assumed that all alcohol consumed has been absorbed into the body and that there is an apparent blood to breath ratio of 2300:1 then the elimination rate required to reconcile the blood and breath results can be calculated. If the elimination rate is less than 40mg/(100ml.h) they can, within the uncertainties inherent in Group C data, be satisfactorily explained. Criterion 9 selects those cases where an elimination rate from blood above this value is required to reconcile the two results. With urine the situation is further complicated by the integrating effect of the bladder and although the alcohol concentration reduces with time the term ‘elimination rate’ when applied to urine is strictly a misnomer. Nevertheless criterion 10 selects all those cases where the elimination rate in urine exceeds 53mg/(100ml.h), assuming a blood to urine ratio of 3:4. This method of calculating the elimination rate required to reconcile two separate tests has, in certain cases, been used to investigate other cases selected by some of the criteria in the list. Criteria 11–18 repeat the process for cases where a second breath test was taken.

The cases in this survey have been divided into three groups (Groups A, B and C; see Section 2.2). The most useful comparisons between breath and blood/urine alcohol levels can be made using data from Groups A and B together with the appropriate criteria, and these have therefore been considered individually. Finally, all data (Groups A, B and C) have been examined using criteria relating to first breath tests.

Consideration of other causes for concern are dealt with elsewhere.

A4 Lion Intoximeter 3000

A4.1 **Comparison of blood and breath results**

A4.1.1 *Group A Cases (Examined using criteria 5 and 15)*

Table A5 shows that there were 817 cases where a blood test had been taken within 10 minutes of a breath test, approximately 75% being the result of a second breath test. There was 1 case (L3/02) selected by criterion 5 where both blood and breath results were borderline i.e. both results near the prosecution limit. The lower breath test result was 40μg/100ml and the reported blood alcohol concentration 78mg/100ml thus putting this case well within the normal range expected. The statutory option range provides a safeguard for cases such as this.

Table A6 shows the apparent blood to breath ratios for all Group A data and confirms the modal value to be in the interval 2300–2399:1. This verifies the apparent blood to breath ratio implicit in the Transport Act. It also shows that it is unusual to obtain an apparent blood to breath ratio below 2000:1.

Although some of the higher ratios are associated with an acetone indication approximately half of the subjects in this group could have a breath alcohol concentration under 40μg/100ml but have a blood alcohol concentration over the statutory limit at the time the breath specimen was taken. These subjects are less likely to be prosecuted on the basis of a breath test than the basis of a blood test.

A4.1.2 *Group B Cases (Examined using criteria 11, 13 and 17)*

There were 670 Group B cases. Table A7 shows the time interval between provision of the laboratory sample and all second breath tests. There were relatively few occasions where the time interval was over 30 minutes.

Amongst the Group B cases there was one (L4/01) where the second breath test result was above the prosecution limit and the reported blood alcohol concentration below the legal limit. The lower breath alcohol concentration was 41μg/100ml and the certified blood alcohol concentration was 79mg/100ml (ie a borderline case).

The blood to breath factors for all Group B cases are shown in Table A8. The modal range is again 2300–2399 c.f. Group A cases.

There were two cases (L1/05) and (L3/13) where the blood to second breath factor was below 1700:1. Subsequent enquiries revealed that both subjects indulged in solvent/gas abuse.

A4.1.3 *All cases (Examined using criteria 1, 3, 7 and 9)*

Table A9 shows that the time interval between the first breath test and the provision of a blood or urine specimen was likely to be just over ½ hour but could be 2 hours or more. The criteria have been used to identify possibly anomalous cases and a summary of the number of responses obtained to these search criteria is given in Table A10. Table A11 lists individual cases involving blood samples which were identified by the various criteria.

Cases identified by Criterion 1 (Breath result > 50µg/100ml, blood result < 81mg/100ml). Table A12 shows each case where the first breath test result was above the statutory option range and the reported blood alcohol concentration was below the legal limit. The figures in the penultimate column give the elimination rates required to reconcile the blood and breath results assuming an apparent blood to breath ratio of 2300:1 and that the subject was in the elimination phase at the time of the breath test. Of the 20 cases listed in Table A12, 9 were associated with solvent or gas abuse. In another case (L3/08) it is understood that prior to the breath test the subject received hospital treatment, the precise nature of which is unknown, but which may explain the discrepancy. Another subject (L3/14) agreed to take a second breath test after provision of the blood sample and this breath test was in excellent agreement with the blood alcohol concentration. This subject was apparently eliminating alcohol from his body at around 28mg/(100ml.h). All the remaining 9 cases indicate acceptable rates of elimination.

Cases identified by criterion 3 (Breath result 40–50µg/100ml, blood result < 81mg/100ml). There were 626 cases identified as possibly anomalous because the first breath test result lay in the statutory option range and the certified blood alcohol concentration was below 81mg/100ml. In 97 cases a further breath test was taken but in 529 cases this was not so. Because of the time interval between provision of the breath and laboratory specimens precise comparisons are not possible. However, of these 529 cases 85 showed a time interval of less than 30 minutes between provision of the breath and blood specimens and 10 showed a time interval of less than 20 minutes. Of these 10 all gave a lower breath alcohol concentration of 42µg/100ml or less and in all cases the analysed blood alcohol concentration was over 80mg/100ml. Hence all 10 cases were borderline. Except for those selected by other criteria none of the 529 could be classified as anomalous. It is not possible to make a more detailed assessment of this group of results but subjects already have the option to supply a laboratory sample where the breath test result is in the statutory option range.

Cases identified by criterion 7 (Blood to breath factor < 1700). The use of blood to breath factors has already been discussed and there were 141 possibly anomalous cases where the factor fell below 1700. Again making the assumption that absorption was complete by the time testing started there were 44 cases where the elimination rate had to exceed 30mg/(100ml.h) and 22 cases where it had to exceed 40mg/(100ml.h) in order to reconcile the blood and breath figures. Hence the anomaly in 119 of the 141 cases could be explained, and the remaining 22 cases are considered below.

Cases identified by criterion 9 (Blood to breath factor < 1700 and required elimination rate > 40mg/(100ml.h). Of the 22 possibly anomalous cases one subject (L2/05) gave very high (and widely divergent) readings on the Intoximeter and a subsequent blood sample was shown to contain acetone, t-butanol, 2-butanone and 2-butanol in addition to ethanol. Further blood and urine specimens provided voluntarily by the subject about a month later were found to contain the same substances at similar concentrations but excluding ethanol and 2-butanol. The laboratory handling the case consulted experts in metabolic disorders who confirmed it was an extremely unusual case. Subsequent information suggested that the subject had a long history of butane inhalation. It is not known which, if any, of the substances found in the blood caused the high readings on the Intoximeter.

In a further case (L2/10) the subject alleged that he had consumed 2 mouthfuls of petrol before the breath test, whilst he had been underneath his car attempting to repair a broken petrol pipe. The police confirmed that his clothing was heavily contaminated with petrol. Even small amounts of petrol can produce toxic effects and whilst the consumption of '2 mouthfuls' may be an overestimate there is a possibility that small amounts of petrol could have been consumed in this case. Petrol vapour will register on the Intoximeter if a sufficiently high concentration is present in the breath sample. Both breath samples yielded results of 90μg/100ml and a blood specimen taken 66 minutes later had a certified blood alcohol concentration of 137mg/100ml. Petrol may have made a contribution to the Intoximeter reading but it is not possible to establish its magnitude.

In two cases (L1/07) and (L1/10) difficulties were encountered in analysing the blood samples and this invalidates any comparison with the breath test result. Therefore it would be incorrect to classify these two results as anomalous.

A further 9 cases from this group of 22 have already been selected by other criteria but for the remaining 9 there is no explanation of the discordant breath and blood results.

A4.1.4 *Summary of comparisons of blood and breath results*

Out of the 1487 cases in the first 2 Groups (A and B) there were no anomalous cases. Because of the generally short time interval between the provision of the blood and breath samples, these two groups form the most useful set of cases on which to judge the performance of the Intoximeter.

The remaining cases consisted of those where a single breath test was taken and the time interval between the breath test and the provision of blood samples was over 10 minutes. This group (Group C) contained 9976 cases and in 11 of these (0.11%) there was no explanation for the discrepancy between the blood and breath results. The time interval between provision of the breath and blood specimens introduces an element of uncertainty into the results and any of the following reasons could explain the discrepancy.

a) The Intoximeter may have been over-estimating the amount of alcohol present.
b) The police may have been unaware that the subject indulged in solvent/gas abuse.
c) The reported times for taking the breath and blood specimens were incorrect.
d) The subject had an abnormally high breath temperature.
e) The subject had a very high elimination rate.
f) Subject was not in elimination phase.
g) Mouth alcohol was present.

A4.2 **Comparisons of urine and breath results**

A4.2.1 *Group A Cases (Examined by criteria 6 and 16)*

There was only one possibly anomalous case (L5/06) from amongst this group of 44. The breath test showed a breath alcohol concentration of 45μg/100ml and the certified urine alcohol concentration was 106mg/100ml. This was within the normal range expected.

A4.2.2 *Group B Cases (Examined using criteria 12, 14 and 18)*

There were 40 Group B cases. In one case (L3/31) both the first and second breath test results were above the statutory option range but the reported urine alcohol concentration was 86mg/100ml. The two breath tests indicated a rate of elimination of alcohol from the breath of 21μg/(100ml.h) (48.3mg/

(10ml.h) in blood) and such high rates of elimination are rare. The high elimination rate combined with the abnormal urine to breath factor suggests the presence in the breath of substances other than alcohol although no evidence for this was received.

There were no cases where the second breath test result was in the statutory option range and the urine alcohol result was below the legal limit.

There were 2 cases where the urine to second breath factor was below 2235:1 (L3/31) and (L3/33). One (L3/31) has already been discussed earlier in this section. The other (L3/33) showed realistic elimination rates on the basis of the two breath tests, but there was no explanation for the disagreement between the breath and urine results.

A4.2.3 *All cases (Examined using criteria 2, 4, 8 and 10)*

Cases Identified by Criterion 2. (Breath result > 50µg/100ml and urine result < 108mg/100ml). There were 9 cases where the breath test result was above the statutory option range and the reported urine alcohol concentration was below the legal limit. Table A14 shows all cases where this occurred and shows the elimination rates required to reconcile the urine and breath results making the assumptions previously discussed (Section A3). The first 3 cases (L2/04), (L3/28) and (L3/30) require elimination rates of less than 53mg/(100ml.h) to reconcile the breath and urine results and are within the limit of acceptability discussed earlier. However, the remaining 6 are above the acceptable limit and are classified as anomalous.

Cases Identified by Criterion 4 (Breath result 40–50µg/100ml, urine result < 108mg/100ml). There were 29 cases where the breath test result fell in the statutory option range and the certified urine alcohol concentration was below 108mg/100ml. In 4 of these cases, the interval between the breath and the urine specimen was less than 30 minutes. In all 4 cases the analysed urine alcohol concentration was above 107mg/100ml but in one case (L5/09) the breath test results were 55 and 48µg/100ml. None of the 29 cases were classified as anomalous.

Cases Identified by Criterion 8 (Urine to breath factor <2235). There were 28 cases where the urine to breath factor was less than 2235:1 and in 20 of these cases the elimination rate required to reconcile the two figures was under 53mg/(100ml.h). Therefore 20 of the 28 cases could be reasonably explained, the others are considered below.

Cases Identified by Criterion 10 (Urine to breath factor <2235:1 and required elimination rate > 53µg/(100ml.h)). Of the 8 cases identified by criterion 10, four have already been mentioned but the remaining 4 required unacceptably high elimination rates to reconcile the urine and breath results and are therefore anomalous.

A4.2.4 *Summary of comparisons of urine and breath results*

There were 44 cases in Group A and none were anomalous.

Of the 40 cases in Group B there were 2 cases (L3/31) and (L3/33) where there was an unexplained discrepancy between the urine and breath results. In the remaining group of 478 cases (Group C) there were 8 cases where there was an unexplained discrepancy between the breath and urine results.

Therefore, overall, out of 562 cases there were 10 (1.78%) in which the discrepancy could not be adequately explained. This is a rate some 16 times greater than that obtained for the blood/breath comparisons. The difficulty in estimating the amount of alcohol in the subject on the basis of a urine test is well established and this fact, rather than any shortcomings in the Intoximeter, probably explains the proportionately higher number of anomalous results associated with subjects supplying urine samples.

A4.3 **Estimation of Rate of Metabolism of Alcohol**

Those cases in which two separate breath tests were taken provided the opportunity to examine the rate of elimination of alcohol from subjects as measured by the Intoximeter. Table A15 shows elimination rates calculated from the mean results of each of two breath tests and demonstrates that approximately 5% of subjects showed a higher result for the 2nd breath test than the first which is evidence that they were still in the absorption phase at the time of the tests. The modal value of 8–9μg/(100ml.h) (18.4–20.7mg/(100ml.h) in blood at an apparent blood to breath ratio of 2300:1) agrees well with the modal value of 19mg/(100ml.h) obtained by Isaacs during laboratory trials.(7) The distribution is skewed towards the lower values also suggesting that many subjects had not fully entered the elimination phase when tested. If subjects, when in the elimination phase, eliminate alcohol from their breath at a rate of at least 5μg/(100ml.h) (11.5mg/(100ml.h) in blood) then 20% of subjects had not fully entered the elimination phase at the time of their first breath test.

Table A15 shows that there were 139 cases where the elimination rate was over 13μg/(100ml.h) (~30mg/(100ml.h) in blood) and 18 cases where the elimination rate exceeded 20μg/(100ml.h).

In order to increase confidence in the calculated elimination rates the breath test data were examined critically and only those cases which met the following selection criteria were included for further consideration.

a) Difference between the two breath samples in both breath tests was less than 7.
b) No acetone indication on first or second test.
c) The time difference between the two breath tests was greater than 20 minutes.

Table A16 gives the resultant table of elimination rates. Although the number of very high elimination rates has been reduced, approximately 5% of subjects appear to have an elimination rate of at least 13μg/(100ml.h) (30mg/(100ml.h) in blood). There were 5 cases (Table A17) where extremely high elimination rates were observed but other parameters were within expected ranges.

A4.3.1 *Conclusion*

The data in Table A17 suggest that some subjects have very high elimination rates and this is supported by observations elsewhere in this survey. If elimination rates of above 40mg/(100ml.h) are attainable more commonly than supposed then this fact may explain some of the cases which have been classified as anomalous.

There appears to be little recent work on the elimination rates in heavy drinkers although it is clearly an area of interest. More work is required to clarify the situation.

A4.4 **Performance of Lion Intoximeter 3000**

A4.4.1 *Acetone detection*

There are two detectors in the Intoximeter 3000, the infra-red cell and the Taguchi cell. The manufacturers state that the former is more sensitive to alcohol than the latter and the converse is true for acetone. The infra-red detector provides the primary reading on which the alcohol result is based and in the absence of any acetone in the breath the result provided by the instrument originates from this detector. If acetone is present in the breath the microprocessor in the Intoximeter detects an imbalance between the infra-red and Taguchi detectors and a deduction is made from the reading obtained from the primary (infra-red) detector to compensate for the amount of acetone found. It is this reduced reading which is displayed on the instrument and printed onto the statement. If the imbalance between the detectors exceeds pre-set levels the presence of acetone is displayed as 'TRACE', 'MODERATE' or 'LARGE' after each sample.

If, acetone is detected in the second breath sample and exceeds a pre-set level then a message ('TRACE', 'MODERATE' or 'LARGE') is printed on the statement. Acetone detected in the first breath sample is indicated on the instrument display but the message is not printed on the statement.

Data provided by Lion Laboratories suggest that 3μg/100ml of acetone in the breath would register as 1μg/100ml on the infra-red detector, and that a breath acetone concentration of at least 15μg/100ml (equivalent to 5mg/100ml in blood) is required to generate a 'TRACE' acetone message and higher concentrations are required to generate 'MODERATE' or 'LARGE' indications.

Prior to this survey it was reported that there were frequent acetone indications on the Intoximeter but there was no medical evidence to suggest that a significant proportion of the population had relatively large amounts of acetone in their breath.

During this survey large numbers of acetone indications at all levels were found. A total of 477 instruments (77%) recorded some type of acetone indication on the first breath test and 204 (33%) recorded at least one 'MODERATE' indication and 106 (17%) gave at least one 'LARGE' indication. Additionally there were 119 instruments (19%) where at least 20% of the tests included an acetone indication.

Overall 10.2% of first breath tests showed an acetone response but there were major variations between the performance of individual instruments. Table A18 gives detailed information on the frequency of acetone indications during each month of the survey. On the basis of this survey it is clear that some instruments are more liable to give acetone indications than others.

Forensic scientists have, for a part of the survey, analysed all blood and urine samples for acetone in addition to alcohol. The acetone concentration in all laboratory samples received following a 'MODERATE' or 'LARGE' acetone indication on the Intoximeter was also determined. (Laboratories were informed by the BAMU of the cases involved.) Only 1.5% of the 4834 samples analysed showed a blood acetone concentration over 1.0mg/100ml (equivalent to approximately 3μg/100ml in breath) and the highest concentration was less than 5mg/100ml in blood (equivalent to approximately 15μg/100ml in breath). On the basis of the manufacturer's figure (5mg/100ml) for the acetone concentration required to promote a 'TRACE' response, none of the blood samples analysed contained enough acetone to cause an acetone message on the Intoximeter.

A summary of the 2920 cases for which a blood or urine acetone concentration and a valid breath test result were available is shown in Table A19. There is no significant difference between either the averages or the ranges of acetone concentrations for the 3 levels of indication. The highest acetone concentration measured for which a breath test was available (3.1mg/100ml) did not trigger an acetone indication. The absence of any reports from the forensic science laboratories of other substances in the blood of subjects showing 'MODERATE' or 'LARGE' acetone indications suggest that these indications are a result of instrument faults. The manufacturers state that if acetone is indicated, a deduction is automatically made from the alcohol reading to compensate for the acetone. If the instrument overestimates the amount of acetone then the alcohol reading will be falsely decreased. If this is correct and the instruments are falsely indicating the presence of acetone, then the net effect will be an under-estimation of the true breath alcohol concentration. Hence in cases where over-compensation occurs, calculation of the apparent blood to breath ratios should show average values higher than the expected 2300:1. Table A20 shows that this does in fact occur and supports the manufacturer's claim that wrongful prosecutions are unlikely even if the acetone detector does malfunction. Indeed, it is probable that some guilty drivers near the prosecution limit could have escaped prosecution because of this problem. In one case (L2/09) a reading of zero was recorded on the Intoximeter with a 'LARGE' acetone indication but subsequent blood analysis showed that the breath alcohol concentration should have been between 50 and 60μg/100ml.

A4.4.2 *Other Interfering Substances*

Ten cases involving solvent or gas abuse have already been mentioned. In at least one of these cases (L6/05) the presence of glue solvents in the breath was not apparent until the subject volunteered the information and in such cases there is a danger that an erroneously high Intoximeter result will be obtained. There was no acetone indication by the Intoximeter in any case involving solvent or gas abuse.

Other than solvents, butane and, possibly, petrol, no other interfering substances were brought to the attention of the BAMU in the course of the survey.

A4.4.3 *The difference between the two breath samples in each breath test*

Replicate blood (or urine) alcohol determinations on a single sample usually provide a set of precise results. Breath testing involves two completely separate samples of breath taken some minutes apart and therefore the same precision as that obtained in the laboratory with blood and urine samples would not be expected. Nevertheless one would expect close agreement between the two breath samples in any breath test.

The modal difference between the first and second breath sample results is 1μg/100ml and 98% of all breath tests show a difference of 10μg/100ml or less. Table A21 shows the differences obtained between first and second samples for first and second breath tests.

Out of 33395 breath tests there were 89 instances (0.26%) where a difference of 20μg/100ml or more was recorded between the two breath sample results and these cases are listed in Table A22. An acetone indication was present in 21 (24%) of these cases. Ignoring time differences and assuming an apparent blood to breath ratio of 2300:1, in approximately half the cases the blood or urine result is in closer agreement to the higher of the 2 breath samples and in the remaining cases the converse is true. Some of the data in Table A22 indicates a fault or the presence of mouth alcohol. One would not normally expect to observe genuine breath alcohol concentrations over 200μg/100ml (equivalent to 460mg/100ml in blood) but the possibility of inveterate alcoholics exceeding this figure cannot be excluded. Large differences may be caused by the manner in which subjects blow into the Intoximeter or a fault in the Intoximeter itself.

Breath difference may be expressed as a percentage of the lower figure and is defined as:

$$\% \text{ Difference} = \frac{(\mathrm{H} - \mathrm{L})}{\mathrm{L}} \times 100$$

where H = higher breath sample result
L = lower breath sample result

In 543 first and second breath tests (1.6%) differences of over 20% were recorded. Table A23 shows that approximately half the differences were 3% or less.

If the lower breath sample result is 20μg/100ml or less, small absolute differences can cause relatively large percentage differences. If all cases where the lower breath sample result is 20μg/100ml or less are excluded, there are 357 cases where the difference between the two breath sample results is 20% or more. However, in almost 40% of the 357 cases these large differences are associated with an acetone indication details of which are given in Table A24.

It was noticed prior to the survey that the first breath sample generally produced a higher result than the second and this phenomenon has also been noted in this survey. Table A25 shows that there were 3 times as many instances where the first breath sample result was higher as vice versa. The reason for this phenomenon is unclear.

A4.4.4 *Data Corruption*

There have been a number of instruments in which some type of data corruption has been observed. Three instruments printed a serial number other than the correct one and this was not always noticed by the operator. A further six instruments showed other miscellaneous data corruption faults.

The acceptable range for the results of the calibration checks made before and after each breath test is 32–37μg/100ml inclusive. One instrument, on two separate occasions failed to record the fact that the result of the second calibration check was out of specification. All the data corruption problems encountered were obvious from the print-out and such print-outs should not be used for prosecution purposes.

A4.4.5 *Printer Problems*

The print quality of the dot-matrix printer varied from the clear to the unreadable. Initially an attempt was made to assess print quality but this was abandoned because of problems encountered in assessment.

A5 Camic Breath Analyser

A5.1 **Comparisons of blood and breath results**

A5.1.1 *Group A cases (Examined using criteria 5 and 15)*

Table A26 shows that there were only 28 Group A cases and Table A27 shows the apparent blood to breath ratios for this small group of results. There are too few results in this group from which to draw firm conclusions. There was one case in this group, (C1/04) where the breath test yielded two results of 46μg/100ml and the reported blood alcohol concentration was 78mg/100ml. The apparent blood to breath ratio was lower than normal but the case has not been classified as anomalous. The statutory option range provides a safeguard for cases such as this.

A5.1.2 *Group B cases (Examined using criteria 11, 13 and 17)*

There were 20 cases in this Group and Table A28 gives the blood to breath factors for Group B data. Table A29 gives the time interval between provision of the blood (or urine) sample and the second breath test for all (Group B) cases.

There were no anomalous cases in this group.

A5.1.3 *All cases (Examined using criteria 1, 3, 7 and 9)*

Table A30 shows the time interval between the first breath test and provision of the blood or urine sample for all cases.

There was only one case (C1/06) where the breath test result was above the statutory option range and the blood alcohol concentration below the legal limit. The breath test results were 64 and 66μg/100ml and the blood specimen, taken 3 hours 3 minutes later, showed a certified blood alcohol concentration of 74mg/100ml. An elimination rate of 22mg/(100ml.h) is required to reconcile these figures which is well within the normal range.

Table A31 shows that there were 33 cases where the breath test result was in the statutory option range but the certified blood alcohol concentration was below the limit. Precise checks on these cases are not possible. In 6 cases the time interval between sampling of the blood and breath was less than 30 minutes. In 2 cases it was less than 20 minutes and the analysed blood alcohol concentration was above 80mg/100ml in both. None of the 33 cases have been classified as anomalous.

There were 7 cases in which the blood to breath factor was below 1700. In 5 of these cases the elimination rate required to reconcile the two results was less than 40mg/(100ml.h) and could therefore be explained. The two remaining cases (C1/01) and (C1/07) required an elimination rate above 40mg/(100ml.h) to reconcile the blood and breath results although in one case (C1/07) problems were encountered during the analysis of the blood sample. Such problem cases have been referred to previously (A4.1.3) and it would be misleading to classify this case as anomalous. However there is no explanation for the remaining case (C1/01).

Table A32 summarises all the possibly anomalous cases.

A5.1.4 *Summary of comparisons of blood and breath results*

There were no anomalous cases amongst either Group A or Group B. There was 1 case in Group C which could not satisfactorily be explained. Therefore out of a total of 576 blood/breath comparisons, one (0.17%) was found to be anomalous. This is approximately the same percentage as that found with the Intoximeter.

A5.2 **Comparisons of urine and breath results**

There were 49 cases in Groups A, B and C none of which were classified as anomalous.

A5.3 **Estimation of Rate of metabolism of alcohol**

Table A33 shows the distribution of elimination rates for the 45 cases where such a calculation was possible. There were two recorded cases where the subject was still in the absorption phase and in approximately 20% of the cases the elimination rate was less than 5μg/(100ml.h) (equivalent to 11.5mg/(100ml.h) in blood). The modal value was between 9 and 10μg/(100ml.h) and all these results are in broad agreement with those obtained on the Intoximeter.

The maximum rate of elimination was found to be in the range 15–16μg/(100ml.h) and refining the data as previously described in section A4.3 did not lower this value. The refined data are shown in Table A34.

A5.4 **Performance of Camic Breath Analyser**

A5.4.1 *Acetone detection*

The Camic Breath Analyser relies on a narrow band-width filter centred at 3.45μm to minimise the interference from acetone and consequently does not have a separate acetone detection system. The Camic system has been described more fully elsewhere(13). In 155 cases the blood or urine specimen was also analysed for acetone and a breath test result was available. In no case was the acetone concentration above 1.0mg/100ml, and there was therefore no opportunity to evaluate the performance of this instrument with respect to acetone.

A5.4.2 *The difference between the two breath samples in each breath test*

Table A35 shows the differences between breath samples for both first and second breath tests. The modal value is 1μg/100ml and 98% of all breath tests show a difference of 12μg/100ml or less. There were 10 cases where the difference was 20μg/100ml or more and these are listed in Table A36. If a blood to breath ratio of 2300:1 is assumed and time differences are ignored then in 3 of the 7 cases where a blood sample was taken the blood result was nearer the lower breath value. The reading of 254μg/100ml was particularly high and was an instrument fault.(12)

There were 33 instances (1.7%) where the breath samples showed differences of over 20%. Table A37 shows that half of the breath differences were found to be 3% or less.

Table A38 shows which of the two breath samples produced the higher result. The data are largely in agreement with those obtained on the Intoximeter (Table A25), the first breath sample result being the higher in the majority of cases.

A5.4.3 *Data corruption*

Data corruption problems have been experienced with the Camic instrument. In a few instances the instrument printed ‘00’ for the year of test. In another instance all values of blanks, standards and breath tests were recorded as zero and the dates and time showed impossible differences. No other data corruption problems were recorded.

A5.4.4 *Printer problems*

The quality of the print-out varied from the clear to the unreadable. Although all figures were well formed the intensity of the printing varied greatly.

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Table A1 Case types in survey and number of results received

Case Type		Number	Percentage of total	No. of cases with blood acetone determinations
1)	Blood or urine result and Intoximeter result	10678	25.7	2441
2)	Blood or urine result and 2 Intoximeter results	1388	3.3	379
3)	Blood or urine result and Camic result	604	1.5	143
4)	Blood or urine result and 2 Camic results	45	0.1	12
5)	Blood or urine result and "failure to provide breath" form	7726	18.6	1759
6)	Intoximeter result only	19517	47.0	
7)	Camic result only	1181	2.8	
8)	As (1) but with "failure to provide breath" form	424	1.0	100
9)	As (3) but with "failure to provide breath" form	2	0.1	
TOTAL		**41565**	**100.0**	**4834**

Table A2 Numbers of case types received from Police Forces

Police Force	Total	Case Type								
		1	2	3	4	5	6	7	8	9
Avon & Somerset	1025	486	0	0	0	143	373	0	23	0
Bedfordshire	507	171	0	0	0	66	262	0	8	0
Cambridgeshire	587	196	0	0	0	172	218	0	1	0
Cheshire	734	247	0	0	0	93	375	0	19	0
City of London	43	10	0	0	0	5	27	0	1	0
Cleveland	308	0	0	85	0	81	0	142	0	0
Cumbria	598	147	1	0	0	167	277	0	6	0
Derbyshire	831	226	0	0	0	147	451	0	7	0
Devon & Cornwall	1224	352	0	0	0	166	680	0	26	0
Dorset	446	218	0	0	0	116	106	0	6	0
Durham	427	0	0	119	0	64	0	244	0	0
Dyfed-Powys	563	148	0	0	0	69	337	0	9	0
Essex	920	372	0	0	0	236	308	0	4	0
Gloucestershire	350	84	0	0	0	99	147	0	20	0
Greater Manchester	1646	315	193	0	0	238	888	0	12	0
Gwent	342	149	57	0	0	25	109	0	2	0
Hampshire	1628	342	0	0	0	411	870	0	5	0
Hertfordshire	389	156	5	0	0	105	114	0	9	0
Humberside	707	195	0	0	0	111	394	0	7	0
Kent	814	247	0	0	0	162	392	0	13	0
Lancashire	1049	172	225	0	0	208	436	0	8	0
Leicestershire	431	132	0	0	0	70	225	0	4	0
Lincolnshire	366	161	0	0	0	46	158	0	1	0
Merseyside	686	316	0	0	0	158	195	0	17	0
Metropolitan	8505	1809	736	0	0	2000	3876	0	84	0
Norfolk	260	75	0	0	0	37	146	0	2	0
North Wales	1057	244	0	0	0	225	579	0	9	0
North Yorkshire	497	1	0	109	45	153	0	188	0	1
Northamptonshire	344	62	0	0	0	72	206	0	4	0
Northumbria	1011	0	0	291	0	112	0	607	0	1
Nottinghamshire	722	133	0	0	0	66	521	0	2	0
South Wales	1176	293	0	0	0	150	723	0	10	0
South Yorkshire	499	184	0	0	0	88	199	0	28	0
Staffordshire	605	178	0	0	0	159	263	0	5	0
Suffolk	523	171	0	0	0	66	286	0	0	0
Surrey	670	341	0	0	0	54	270	0	5	0
Sussex	1576	191	111	0	0	354	910	0	10	0
Thames Valley	1553	518	0	0	0	223	802	0	10	0
Warwickshire	309	59	10	0	0	92	147	0	1	0
West Mercia	783	242	0	0	0	199	337	0	5	0
West Midlands	2416	608	0	0	0	283	1497	0	28	0
West Yorkshire	2096	628	0	0	0	176	1281	0	11	0
Wiltshire	342	99	50	0	0	59	132	0	2	0
TOTAL	**41565**	**10678**	**1388**	**604**	**45**	**7726**	**19517**	**1181**	**424**	**2**

Table A3 Numbers of cases in each category where a valid breath test was not completed

Reason	No.	Percentage of total non-breath cases
Instrument not available	3308	40.6
Operator not available	681	8.4
Driver patient in hospital	1186	14.5
Unable to blow for medical reasons	694	8.5
First calibration check out of specification	743	9.1
Unable to blow for non-medical reasons	294	3.6
Second calibration check out of specification	635	7.8
Any other reason	346	4.2
Form incomplete/not received	265	3.3
Total number of 'no breath test' cases	**8152**	**100**

Table A4 Some reasons for incomplete breath tests and no laboratory specimen taken

1. Driver refused to take breath test
2. Driver supplied first but not second breath sample
3. First breath sample below limit and test abandoned
4. Second calibration check out of specification and subject refused blood/urine test
5. Instrument failed after 1st breath sample and doctor unavailable.
6. Instrument and doctor unavailable.
7. Information on print-out unreadable
8. Second calibration check out of specification – not noticed by operator
9. Breath test taken but subject allegedly stole urine sample
10. Reason unknown

Table A5 LION INTOXIMETER 3000 Cases which included a laboratory sample

	Time interval between breath and blood or urine samples			
	One or both under 10 mins	All over 10 mins	Not known	Total No. of Cases
Blood Cases				
Single breath test	181	9976	30	10187
Dual breath test	636	670	1	1307
Total (Blood)	817	10646	31	11494
Urine Cases				
Single breath test	3	478	10	491
Dual breath test	41	40	0	81
Total (Urine)	44	518	10	572
GRAND TOTAL	**861**	**11164**	**41**	**12066**

Table A6 LION INTOXIMETER 3000 Apparent blood to breath ratios for specimens taken within 10 minutes of each other (Group A data)

Apparent Ratio	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
1900–1999	4	0.5	0.5
2000–2099	19	2.3	2.8
2100–2199	68	8.3	11.1
2200–2299	124	15.2	26.3
2300–2399	180	22.1	48.4
2400–2499	129	15.8	64.2
2500–2599	118	14.5	78.7
2600–2699	66	8.1	86.8
2700–2799	39	4.8	91.6
2800–2899	26	3.2	94.8
2900–2999	15	1.8	96.6
3000–3099	13	1.6	98.2
3100 and over	14	1.8	100.0
TOTAL	**815***		

*Out of a total of 817. In cases where the lower breath sample result was 10μg/100ml or less the ratio was not calculated.

Table A7 LION INTOXIMETER 3000 Time interval between blood or urine specimen and second breath test

Time interval (mins.)	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
0	5	0.4	0.4
1	12	0.9	1.3
2	10	0.7	2.0
3	39	2.8	4.8
4	33	2.4	7.2
5	53	3.8	11.0
6	85	6.1	17.1
7	88	6.3	23.4
8	113	8.1	31.5
9	120	8.6	40.1
10	104	7.5	47.6
11	115	8.3	57.9
12	99	7.1	63.0
13	66	4.8	67.8
14	69	5.0	72.8
15	57	4.1	76.9
16	57	4.1	81.0
17	41	3.0	84.0
18	26	1.9	85.9
19	31	2.2	88.1
20	19	1.4	89.5
21	13	0.9	90.4
22	7	0.5	90.9
23	12	0.9	91.8
24	8	0.6	92.4
25	9	0.6	93.0
26	8	0.6	93.6
27	8	0.6	94.2
28	5	0.4	94.6
29	5	0.4	95.0
30	7	0.5	95.5
Over 30 or not known	64	4.5	100.0
TOTAL	**1388**		

Table A8 LION INTOXIMETER 3000 Blood to breath factors for Group B data

Factor	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
200– 299	1	0.1	0.1
1100–1199	1	0.1	0.2
1800–1899	2	0.3	0.5
1900–1999	3	0.4	0.9
2000–2099	12	1.8	2.7
2100–2199	34	5.1	7.8
2200–2299	85	12.7	20.5
2300–2399	118	17.6	38.1
2400–2499	102	15.2	53.3
2500–2599	113	16.9	70.2
2600–2699	70	10.5	80.7
2700–2799	52	7.8	88.5
2800–2899	30	4.5	93.0
2900–2999	9	1.3	94.3
3000–3099	17	2.5	96.8
3100 and over	20	3.0	100.0
TOTAL	**669***		

*Out of 670. In one case the lower breath sample result was 10μg/100ml or less and the ratio was not calculated.

Table A9 LION INTOXIMETER 3000 Time interval between first breath test and blood or urine specimen

Time Interval (mins)	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
0– 4	71	0.6	0.6
5– 9	138	1.1	1.7
10– 14	273	2.2	3.9
15– 19	532	4.3	8.2
20– 24	1131	9.1	17.3
25– 29	1700	13.6	30.9
30– 34	1760	14.1	45.0
35– 39	1631	13.1	58.1
40– 44	1324	10.6	68.7
45– 49	962	7.7	76.4
50– 54	715	5.7	82.1
55– 59	519	4.2	86.3
60– 64	413	3.3	89.6
65– 69	279	2.2	91.8
70– 74	245	2.0	93.8
75– 79	163	1.3	95.1
80– 84	142	1.1	96.2
85– 89	101	0.8	97.0
90– 94	97	0.8	97.8
95– 99	59	0.5	98.3
100–104	39	0.3	98.6
105–109	37	0.3	98.9
110–114	28	0.2	99.1
115–119	27	0.2	99.3
120 and above or not known	104	0.7	100.0
TOTAL	**12490**		

Table A10 LION INTOXIMETER 3000 Summary of possibly anomalous cases selected by the criteria listed

Criterion No.	Criteria	Responses
1	1st breath test >50, blood <81	20
2	1st breath test >50, urine <108	9
3	1st breath test 40–50, blood <81	626
4	1st breath test 40–50, urine <108	29
5	1st breath test 40–50, blood <81, time diff <10 mins	1
6	1st breath test 40–50, urine <108, time diff <10 mins	1
7	Blood to 1st breath test factor <1700	141
8	Urine to 1st breath test factor <2235	28
9	Blood to 1st breath test factor <1700, elim >40mg/(100ml.h)	22
10	Urine to 1st breath test factor <2235, elim >53mg/(100ml.h)	8
11	2nd breath test >50, blood <81	NIL
12	2nd breath test >50, urine <108	1
13	2nd breath test 40–50, blood <81	1
14	2nd breath test 40–50, urine <108	NIL
15	2nd breath test 40–50, blood <81, time diff <10 mins	NIL
16	2nd breath test 40–50, urine <108, time diff <10 mins	NIL
17	Blood to 2nd breath test factor <1700	2
18	Urine to 2nd breath test factor <2235	2

Notes. Breath figures in μg/100ml
Blood or urine figures in mg/100ml
All blood and urine figures are *certificate* values.
'Breath test' refers to the lower result obtained from a pair of breath samples.

Table A11 LION INTOXIMETER 3000 Possibly anomalous cases involving blood specimens identified by the criteria shown

Case No.	Time Interval Br 1 (Mins)	Time Interval Br 2 (Mins)	Criteria† 1	5	9	11	13	15	17	Elimination rate required to reconcile blood and breath (mg/100ml.h)	Comment
L1/03	65				X					45	Anomalous
L1/04	61				X					45	Anomalous
L1/05	60	45							X	—	Butane sniffer
L1/06	154		X							19	Acceptable
L1/07	11				X					—	Doubtful blood result
L1/10	27				X					60	Doubtful blood result
L2/05	90				X					—	Anomalous*
L2/07	44		X		X					—	Glue sniffer
L2/10	66				X					55	Possible petrol contamination
L3/02	10			X						—	Acceptable
L3/03	89		X							33	Acceptable
L3/06	99		X							27	Acceptable
L3/07	30		X		X					226	Glue sniffer
L3/08	24		X		X					108	Anomalous
L3/09	132		X							31	Acceptable
L3/10	108				X					42	Anomalous
L3/11	78		X		X					—	Glue sniffer
L3/12	76				X					46	Anomalous
L3/13	47	37	X						X	—	Glue sniffer
L3/14	97	9	X							0	Good agreement on 2nd breath
L3/16	86		X		X					—	Butane sniffer
L3/20	138		X							24	Acceptable
L4/01	45	11					X			—	Acceptable
L4/05	103				X					47	Anomalous
L4/07	72		X							36	Acceptable
L4/11	139		X							20	Acceptable
L5/03	94		X							22	Acceptable
L5/08	54		X		X					83	Glue sniffer
L6/01	21		X		X					—	Glue sniffer
L6/05	49		X		X					71	Glue sniffer
L6/06	18		X		X					—	Glue sniffer
L6/07	20				X					108	Anomalous
L7/06	102		X							29	Acceptable

Table A11 (contd) LION INTOXIMETER 3000 Possibly anomalous cases involving blood specimens identified by the criteria shown

Case No.	Time Interval		Criteria†							Elimination rate required to reconcile blood and breath	Comment
	Br 1 Mins	Br 2 Mins	1	5	9	11	13	15	17	(mg/100ml.h)	
L7/12	25				X					146	Anomalous
L7/13	28				X					54	Anomalous
L7/15	39				X					89	Anomalous

Time Interval
Br1 1st breath test to blood sample
Br2 2nd breath test to blood sample
†See text for details of criteria 3 and 7
*Unusual substances in blood, possibly due to long history of "butane sniffing".

Table A12 LION INTOXIMETER 3000 Cases in which the 1st breath test result was over 50µg/100ml but reported blood alcohol result under 81mg/100ml

Case No.	Breath Sample (µg/100ml)		Blood Alcohol concentration (mg/100ml)		Interval	Lower breath: blood equiv. (mg/100ml)	Elimination rate required to reconcile blood and breath results (mg/(100ml.h))	Comment
	1	2	Analysed	Reported				
L1/06	53	51	67	61	154	117	19	
L2/07	123	136	0	0	44	—	—	Glue sniffer
L3/03	56	52	71	65	89	120	33	
L3/06	52	52	76	70	99	120	27	
L3/07	79	74	57	51	30	170	226	Glue sniffer
L3/08	57	54	81	75	24	124	107	Hospital before test
L3/09	58	52	51	45	132	120	31	
L3/11	66	69	0	0	78	—	—	Glue sniffer
L3/13	56	66	0	0	47	—	—	Glue sniffer
2nd test	28	27	0	0	37			
L3/14	56	51	71	65	97	117	28	
2nd test	35	31			9	71	Zero	
L3/16	488	387	0	0	86	—	—	Butane sniffer
L3/20	65	61	85	79	138	140	24	
L4/07	55	54	81	75	72	124	36	
L4/11	54	54	78	72	139	124	20	
L5/03	51	53	82	76	94	117	22	
L5/08	150	134	58	52	54	133	83	Glue sniffer
L6/01	82	71	0	0	21	—	—	Glue sniffer
L6/05	54	51	59	53	49	117	71	Glue sniffer
L6/06	85	104	65	59	18	196	437	Glue sniffer
L7/06	56	55	78	72	102	127	29	

Table A13 LION INTOXIMETER 3000 Possibly anomalous cases involving urine specimens, identified by the criteria shown

Case No.	Time Interval		Criteria†							Elimination rate required to reconcile urine and breath results (mg/(100ml.h))	Comment
	Br 1 (Mins)	Br 2 (Mins)	2	6	10	12	14	16	18		
L2/04	64		X							46	Acceptable
L3/28	62		X							52	Acceptable
L3/29	52				X					70	Anomalous
L3/30	85		X							46	Acceptable
L3/31	45	14	X			X			X	—	Anomalous
L3/32	28		X		X					174	Anomalous
L3/33	64	17	X						X	—	Anomalous
L3/34	55		X		X					57	Anomalous
L4/04	30				X					136	Anomalous
L5/04	64				X					80	Anomalous
L5/05	59		X		X					83	Anomalous
L5/06	5			X						—	Acceptable
L6/03	28		X		X					94	Anomalous
L7/11	68				X					64	Anomalous

†See text for details of criteria 4 and 8

Time Interval
Br1 1st breath test to urine sample
Br2 2nd breath test to urine sample

Table A14 LION INTOXIMETER 3000 Cases in which the 1st breath test result was over 50μg/100ml but reported urine alcohol result under 108mg/100ml

Case No.	Breath Sample (μg/100ml)		Urine Alcohol (mg/100ml)		Time Interval (mins)	Lower breath sample: urine equiv. (mg/100ml)	Elimination rate required to reconcile urine and breath results (mg/(100ml.h))
	1	2	Analysed	Reported			
L2/04	55	53	113	106	64	163	47
L3/28	51	51	102	95	62	156	52
L3/30	52	55	94	88	85	159	46
L3/31	90	87	92	86	45	267	233
2nd test	67	68			14	—	—
L3/32	62	60	103	96	28	184	174
L3/33	57	57	58	52	64	175	110
2nd test	42	33			17	—	—
L3/34	51	52	104	97	55	156	57
L5/05	61	61	105	98	59	187	83
L6/03	51	51	112	105	28	156	94

Table A15 LION INTOXIMETER 3000 Rate of elimination of alcohol from breath calculated from the mean result in each of two breath tests

Elimination rate (μg/(100ml.h))	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
Absorbing	70	5.0	5.0
<1	5	0.4	5.4
1–2	44	3.2	8.6
2–3	42	3.0	11.6
3–4	53	3.8	15.4
4–5	63	4.5	19.9
5–6	98	7.1	27.0
6–7	135	9.7	36.7
7–8	128	9.2	45.9
8–9	171	12.3	58.3
9–10	158	11.4	69.6
10–11	115	8.3	77.9
11–12	95	6.8	84.2
12–13	72	5.2	89.9
13–14	48	3.5	93.2
14–15	23	1.7	95.1
15–16	22	1.6	96.7
16–17	7	0.5	97.2
17–18	9	0.6	97.8
18–19	7	0.5	98.3
19–20	5	0.4	98.7
20–21	1	0.1	98.8
21–22	2	0.1	98.9
22–23	3	0.2	99.1
23–24	4	0.3	99.4
24–25	1	0.1	99.5
25 and over	7	0.5	100.0
TOTAL	**1388**		

Table A16 LION INTOXIMETER 3000 Rate of elimination of alcohol from breath calculated from the mean result in each of two breath tests – Refined data

Elimination rate (μg/(100ml.h))	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
Absorbing	41	3.8	3.8
<1	5	0.5	4.2
1–2	39	3.6	7.8
2–3	34	3.1	10.9
3–4	42	3.9	14.8
4–5	51	4.7	19.5
5–6	81	7.5	27.0
6–7	107	9.8	36.8
7–8	106	9.8	46.6
8–9	131	12.1	58.6
9–10	140	12.9	71.5
10–11	81	7.5	78.9
11–12	82	7.5	86.5
12–13	61	5.6	92.1
13–14	31	2.9	94.9
14–15	18	1.7	96.6
15–16	12	1.1	97.7
16–17	5	0.5	98.2
17–18	7	0.6	98.8
18–19	4	0.4	99.2
19–20	4	0.4	99.5
20–21	0	0.0	99.5
21–22	1	0.1	99.6
22–23	2	0.2	99.8
23–24	1	0.1	99.9
24–25	0	0.0	99.9
25 and over	1	0.1	100.0
TOTAL	**1087**		

Table A17 LION INTOXIMETER 3000 Cases showing elimination rates from blood of over 40mg/(100ml.h)

Case No.	Breath Test 1		Breath Test 2		Time Interval (Mins) (1)	Bl/Br Factor (2)	Elim. in Breath (µg/(100ml.h))	Equivalent elimination rate in blood (mg/(100ml.h))	
	Sample 1	Sample 2	Sample 1	Sample 2				@ 2300:1	@ Factor Found
L3/19	123	122	104	100	65	2539:1	18.5	42.5	47.0
L3/22	46	45	34	32	30	2375:1	24	55.2	57.0
L3/27	125	127	101	98	61	2591:1	25.6	58.9	66.3
L4/06	138	138	123	121	42	2256:1	22.9	52.7	51.7
L4/10	63	58	45	42	46	2857:1	22.2	51.1	63.4

Notes
(1) Between breath tests
(2) Based on the blood sample and the nearest breath test chronologically

Table A18 LION INTOXIMETER 3000 Acetone Indications by month for first breath test only

INDICATION	APRIL*			MAY			JUNE			JULY		
	No	%	Cum %	No	%	Cum %	No	%	Cum %	No	%	Cum %
TRACE	250	9.9	9.9	518	9.7	9.7	357	6.8	6.8	385	6.9	6.9
MODERATE	50	2.0	11.8	104	1.9	11.6	99	1.9	8.7	84	1.5	8.4
LARGE	36	1.4	13.3	49	0.9	12.6	41	0.8	9.5	36	0.6	9.1
NONE	2198	86.7	100.0	4673	87.4	100.0	4736	90.5	100.0	5070	90.9	100.0
TOTAL	**2534**			**5344**			**5233**			**5575**		

INDICATION	AUGUST			SEPTEMBER			OCTOBER*		
	No	%	Cum %	No	%	Cum %	No	%	Cum %
TRACE	326	6.0	6.0	470	8.7	8.7	186	7.4	7.4
MODERATE	69	1.3	7.3	88	1.6	10.3	33	1.3	8.7
LARGE	32	0.6	7.9	40	0.7	11.1	10	0.4	9.1
NONE	4967	92.1	100.0	4795	88.9	100.0	2297	90.9	100.0
TOTAL	**5394**			**5393**			**2526**		

*cases collected for 2 weeks only in each of these months

Table A19 LION INTOXIMETER 3000 Relationship between breath acetone indication and blood or urine acetone concentration – 1st breath test only

Indication on Intoximeter	No of Cases	Mean blood acetone concentration (mg/100ml)	Range (mg/100ml)
NONE	2399	0.28	0.00–3.13
TRACE	220	0.31	0.00–1.71
MODERATE	199	0.28	0.00–1.71
LARGE	102	0.29	0.00–0.90

Table A20 LION INTOXIMETER 3000 Blood to breath factor where breath acetone was indicated and the blood specimen was taken within 30 minutes of the breath test

Acetone Indication	Mean Factor	Standard Deviation	No. of Cases
NONE	2273	217	3185
TRACE	2471	276	299
MODERATE	2638	254	78
LARGE	3017	341	33

Table A21 LION INTOXIMETER 3000 Difference between first and second breath samples for both first and second breath tests

Sample Difference (µg/100ml)	Frequency			Relative Frequency (%)	Cumulative Frequency (%)
	1st Breath Test	2nd Breath Test	Total		
0	4041	208	4249	12.7	12.7
1	7308	360	7668	23.0	35.7
2	6205	311	6516	19.5	55.2
3	4819	194	5013	15.0	70.2
4	3315	131	3446	10.3	80.5
5	2231	79	2310	6.9	87.4
6	1404	42	1446	4.3	91.7
7	893	21	914	2.7	94.4
8	527	14	541	1.6	96.0
9	349	9	358	1.1	97.1
10	240	5	245	0.7	97.8
11	204	2	206	0.6	98.4
12	115	2	117	0.4	98.8
13	84	1	85	0.3	99.1
14	51	1	52	0.2	99.3
15	44	1	45	0.1	99.4
16	37	0	37	0.1	99.5
17	22	1	23	0.1	99.6
18	18	2	20	0.1	99.7
19	14	1	15	0.1	99.8
20	8	0	8	0.1	
Over 20	78	3	81	0.2	100.0
TOTALS	**32007**	**1388**	**33395**		

Table A22 LION INTOXIMETER 3000 Individual cases involving breath sample differences of 20μg/100ml or more

Lab Ref.	B U	Blood/ Urine (Analysed)	BrAC† Equiv	Breath Test 1		Breath Test 2		Breath Sample Nearest Blood/Urine*	Sample Diff.		Acet. Ind.
				Sample 1	Sample 2	Sample 1	Sample 2		Test 1	Test 2	
L/01				151	121				030		
L/02				128	100				028		
L/03				066	087				021		
L/04				044	023				021		L
L/05				060	029				031		
L/06				140	120				020		
L/07				110	056				054		
L/08				106	086				020		
L/09				100	078				022		
L/10				168	132				036		
L/11				106	080				026		
L/12				107	084				023		
L/13				065	096				031		
L/14				118	079				039		T
L/15				094	067				027		
L/16				114	092				022		
L/17				088	060				028		
L/18				056	033				023		
L/19				029	058				029		
L/20				118	084				034		
L/21				061	081				020		
L/22				034	007				027		
L/23				000	030				030		
L/24				114	091				023		
L/25				129	108				021		T
L/26				120	083				037		
L/27				025	045				020		
L/28				032	008				024		L
L/29				058	082				024		
L/30				020	062				042		
L/31				117	087				030		M
L/32				122	093				029		
L/33				069	089				020		
L/34				069	091				022		
L/35				083	057				026		
L/36				128	105				023		
L/37				077	098				021		
L1/01	B	243	106	111	085			higher	026		L
L1/02	B	232	101	109	084			higher	025		
L1/05	B	102	44	196	223	103	089	lower	027	014	
L1/08	B	218	95	106	077			higher	029		
L1/09	B	121	53	000	029			higher	029		L
L2/01	B	148	64	072	048			higher	024		T
L2/02	B	271	118	102	123			higher	021		
L2/03	B	312	136	157	134			lower	023		
L2/05	B	119	52	253	342			lower	089		
L2/06	U	286	93	072	107			higher	035		
L2/08	B	174	76	056	032			higher	024		L
L2/11	B	144	63	243	066			lower	177		
L3/01	B	149	65	083	059			lower	024		
L3/04	B	196	85	000	101			higher	101		
L3/05	B	162	70	104	076			lower	028		
L3/15	B	208	90	093	055	087	081	higher	038	006	L
L3/16	B	006	000	488	387			——	101		
L3/17	B	112	49	000	052			higher	052		
L3/18	B	093	40	041	041	062	035	lower	000	027	
L3/21	B	171	74	094	063	043	079	lower TEST 1 higher TEST 2	031	036	L
L3/23	B	127	55	060	143			lower	083		
L3/24	B	104	45	015	035			higher	020		
L3/25	B	262	114	093	117	083	094	higher	024	011	
L3/26	B	164	71	076	000			higher	076		L
L4/02	B	039	17	051	000	011	023	lower	051	012	M

*Comparison relates to the breath test showing the large sample difference
†Breath Alcohol Concentration

Table A22 (contd) LION INTOXIMETER 3000 Individual cases involving breath sample differences of 20μg/100ml or more

Lab Ref.	B U	Blood/ Urine (Analysed)	BrAC† Equiv	Breath Test 1		Breath Test 2		Breath Sample Nearest Blood/Urine*	Sample Diff.		Acet. Ind.
				Sample 1	Sample 2	Sample 1	Sample 2		Test 1	Test 2	
L4/03	B	054	23	000	021			higher	021		
L4/08	B	130	57	106	069			lower	037		
L4/09	B	127	55	106	065			lower	041		
L4/12	B	199	87	102	055			higher	047		M
L4/13	B	127	55	081	001			higher	080		
L4/14	B	194	84	075	095			lower	020		T
L5/01	B	183	80	088	496			lower	408		
L5/02	U	386	126	159	139			lower	020		
L5/07	B	115	50	057	029			higher	028		T
L6/02	B	179	78	053	079			higher	026		
L6/04	B	185	80	088	048			higher	040		T
L6/08	B	270	117	146	124			lower	022		
L6/09	B	128	56	000	056			higher	056		
L6/10	B	247	107	120	078			higher	042		L
L7/01	B	152	66	148	072			lower	076		T
L7/02	B	081	35	289	041			lower	248		
L7/03	B	365	159	185	138			lower	047		
L7/04	B	303	132	139	117			higher	022		
L7/05	B	088	38	042	151			lower	109		
L7/07	B	155	67	071	050			higher	021		L
L7/08	B	080	35	041	042	057	035	lower	001	022	
L7/09	B	250	109	116	072			higher	044		T
L7/10	B	084	37	186	039			lower	147		
L7/14	B	075	33	034	102			lower	068		
L7/16	B	186	81	117	094			lower	023		
L7/17	B	110	48	092	053			lower	039		

*Comparison relates to the breath test showing the large sample difference
†Breath Alcohol Concentration

Table A23 LION INTOXIMETER 3000 Difference between two breath samples expressed as a percentage of lower sample for 1st and 2nd breath tests

Difference (%)	Frequency			Relative Frequency (%)	Cumulative Frequency (%)
	1st Breath test	2nd Breath test	Total		
0	4083	208	4291	12.8	12.8
1	2913	81	2994	9.0	21.8
2	4922	242	5164	15.4	37.2
3	3427	186	3613	10.8	48.0
4	3350	131	3481	10.4	58.4
5	2733	132	2865	8.6	67.0
6	2258	77	2335	7.0	74.0
7	1964	75	2039	6.1	80.1
8	1245	63	1308	3.9	84.0
9	1053	51	1104	3.3	87.3
10	817	29	846	2.5	89.8
11	613	23	636	1.9	91.7
12	481	19	500	1.5	93.2
13	406	20	426	1.3	94.5
14	314	11	325	1.0	95.5
15	247	4	251	0.8	96.3
16	181	6	187	0.6	96.9
17	170	3	173	0.5	97.4
18	118	2	120	0.4	97.8
19	101	0	101	0.3	98.1
20	93	0	93	0.3	98.4
Over 20	518	25	543	1.6	100.0
TOTALS	**32007**	**1388**	**33395**		

Table A24 LION INTOXIMETER 3000 Occurrence of acetone indications associated with breath sample differences of over 20% and lower breath result over 20μg/100ml

Indication	Number	Percentage	Cumulative Percentage
TRACE	64	17.9	17.9
MODERATE	28	7.8	25.7
LARGE	40	11.2	36.9
NONE	225	63.1	100.0

Table A25 LION INTOXIMETER 3000 Occurrence of the higher breath sample result within a breath test

	Frequency	Percentage
1st result higher	20580	64.3
Results equal	4041	12.6
2nd result higher	7386	23.1
	32007	

Table A26 CAMIC BREATH ANALYSER Cases which included a laboratory sample

	Time interval between breath and blood or urine samples			Total No. of Cases
	One or both under 10 mins	All over 10 mins	Not known	
Blood Cases				
Single breath test	14	548	2	564
Dual breath test	14	20	1	35
Total (Blood)	28	568	3	599
Urine Cases				
Single breath test	1	38	1	40
Dual breath test	5	5	0	10
Total (Urine)	6	43	1	50
GRAND TOTAL	**34**	**611**	**4**	**649**

Table A27 CAMIC BREATH ANALYSER Apparent blood to breath ratios for specimens taken within 10 minutes of each other (Group A data)

Apparent Ratio	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
1800–1899	1	3.6	3.6
2100–2199	1	3.6	7.2
2300–2399	3	10.7	17.9
2400–2499	7	25.0	42.9
2500–2599	4	14.3	57.2
2600–2699	5	17.9	75.1
2700–2799	4	14.3	89.4
2800–2899	2	7.1	96.5
3000–3099	1	3.6	100.0
TOTAL	**28**		

Table A28 CAMIC BREATH ANALYSER Blood to breath factors for Group B data

Factor	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
2300–2399	6	30.0	30.0
2400–2499	6	30.0	60.0
2500–2599	4	20.0	80.0
2600–2699	2	10.0	90.0
2700–2799	2	10.0	100.0
TOTAL	**20**		

Table A29 CAMIC BREATH ANALYSER Time interval between blood or urine specimen and second breath test

Time Interval (mins.)	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
5	2	4.4	4.4
6	1	2.2	6.6
7	4	8.9	15.5
8	4	8.9	24.4
9	6	13.3	37.7
10	2	4.4	42.1
11	7	15.6	57.7
12	3	6.7	64.4
13	2	4.4	68.8
14	1	2.2	71.0
15	3	6.7	77.7
16	2	4.4	82.1
17	2	4.4	86.5
18	0		
19	0		
20	1	2.2	88.7
21	0		
22	0		
23	1	2.2	90.9
24	1	2.2	93.1
25	0		
26	1	2.2	95.3
27	0		
28	1	2.2	97.5
29	0		
30	0		
Over 30 or not known	1	2.2	100.0
TOTAL	**45**		

Table A30 CAMIC BREATH ANALYSER Time interval between first breath test and blood or urine specimen

Time Interval (mins.)	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
0–4	5	0.8	0.8
5–9	9	1.4	2.2
10–14	15	2.3	4.5
15–19	29	4.5	9.0
20–24	76	11.7	20.7
25–29	72	11.0	31.7
30–34	80	12.3	44.0
35–39	86	13.2	57.2
40–44	61	9.4	66.6
45–49	55	8.4	75.0
50–54	53	8.1	83.1
55–59	21	3.2	86.3
60–64	21	3.2	89.5
65–69	18	2.8	92.3
70–74	12	1.8	94.1
75–79	8	1.2	95.3
80–84	5	0.8	96.1
85–89	2	0.3	96.4
90–94	3	0.5	96.9
95–99	5	0.8	97.7
100–104	2	0.3	98.0
105–109	4	0.6	98.6
110–114	1	0.2	98.8
115–119	0	0.0	98.8
120 and over or not known	8	1.2	100.0
TOTAL	**651**		

Table A31 CAMIC BREATH ANALYSER Summary of possibly anomalous cases selected by the criteria listed

Criterion No.	Criteria	Responses
1	1st breath test >50, blood <81	1
2	1st breath test >50, urine <108	NIL
3	1st breath test 40–50, blood <81	33
4	1st breath test 40–50, urine <108	2
5	1st breath test 40–50, blood <81, time diff <10 mins	1
6	1st breath test 40–50, urine <108, time diff <10 mins	NIL
7	Blood to 1st breath test factor <1700	7
8	Urine to 1st breath test factor <2235	NIL
9	Blood to 1st breath test factor <1700, elim >40mg/(100ml.h)	2
10	Urine to 1st breath test factor <2235, elim >53mg/(100ml.h)	NIL
11	2nd breath test >50, blood <81	NIL
12	2nd breath test >50, urine <108	NIL
13	2nd breath test 40–50, blood <81	NIL
14	2nd breath test 40–50, urine <108	NIL
15	2nd breath test 40–50, blood <81, time diff <10 mins	NIL
16	2nd breath test 40–50, urine <108, time diff <10 mins	NIL
17	Blood to 2nd breath test factor <1700	NIL
18	Urine to 2nd breath test factor <2235	NIL

Notes. Breath figures in μg/100ml
Blood or urine figures in mg/100ml
All blood and urine figures are *certificate* values
'Breath test' refers to the lower result obtained from a pair of breath samples.

Table A32 CAMIC BREATH ANALYSER Possibly anomalous cases involving blood specimens identified by the critieria shown

Case No.	Time Interval Br 1 (mins)	Time Interval Br 2 (mins)	Criteria† 1	Criteria† 5	Criteria† 9	Criteria† 11	Criteria† 13	Criteria† 15	Criteria† 17	Elimination rate required to reconcile the blood and breath results (mg/(100ml.h))	Comment
C1/01	39				X					43	Anomalous
C1/04	10			X							Acceptable
C1/06	183		X								Acceptable
C1/07	23				X					89	Doubtful blood result

†see text for details of criteria 3 and 7

Table A33 CAMIC BREATH ANALYSER Rate of elimination of alcohol from breath calculated from the mean result in each of two breath tests

Elimination rate (μg/(100ml.h))	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
Absorbing	2	4.4	4.4
<1	0	0	4.4
1–2	2	4.4	8.8
2–3	2	4.4	13.2
3–4	1	2.2	15.4
4–5	3	6.7	22.1
5–6	3	6.7	28.8
6–7	2	4.4	33.2
7–8	7	15.6	48.8
8–9	5	11.1	59.9
9–10	9	20.0	79.9
10–11	2	4.4	84.3
11–12	4	8.9	93.2
12–13	0	0	93.2
13–14	1	2.2	95.4
14–15	0	0	95.4
15–16	2	4.4	100.0
16 and over	0	0	
TOTAL	**45**		

Table A34 CAMIC BREATH ANALYSER Rate of elimination of alcohol from breath calculated from the mean result in each of two breath tests – Refined data

Elimination rate (μg/(100ml.h))	Frequency	Relative Frequency (%)	Cumulative Frequency (%)
Absorbing	1	2.7	2.7
<1	0	0	2.7
1–2	1	2.7	5.4
2–3	0	0	5.4
3–4	1	2.7	8.1
4–5	3	8.1	16.2
5–6	3	8.1	24.3
6–7	2	5.4	29.7
7–8	6	16.2	45.9
8–9	5	13.5	59.4
9–10	7	18.9	78.3
10–11	2	5.4	83.7
11–12	3	8.1	91.8
12–13	0	0	91.8
13–14	1	2.7	94.5
14–15	0	0	94.5
15–16	2	5.4	100.0
16 and over	0	0	
TOTAL	**37**		

Table A35 CAMIC BREATH ANALYSER Difference between first and second breath samples for both first and second breath tests

Sample Difference (μg/100ml)	Frequency 1st Breath Test	 2nd Breath Test	 Total	Relative Frequency (%)	Cumulative Frequency (%)
0	239	5	244	13.0	13.0
1	396	17	413	22.0	35.0
2	366	10	376	20.0	55.0
3	262	4	266	14.2	69.2
4	172	1	173	9.2	78.4
5	121	3	124	6.6	85.0
6	80	2	82	4.3	89.3
7	52	0	52	2.7	92.0
8	42	1	43	2.2	94.2
9	33	0	33	1.7	95.9
10	16	2	18	1.0	96.9
11	14		14	0.7	97.6
12	6		6	0.3	97.9
13	7		7	0.4	98.3
14	5		5	0.3	98.6
15	0		0	0.0	98.6
16	1		1	0.1	98.7
17	4		4	0.2	98.9
18	2		2	0.1	99.0
19	4		4	0.2	99.2
20	1		1	0.1	99.3
Over 20	9	0	9	0.5	100.0
TOTAL	**1832**	**45**	**1877**		

Table A36 CAMIC BREATH ANALYSER Individual cases involving breath sample differences of 20μg/100ml or more

Lab Ref.	B U	Blood/ Urine Analysed	BrAC† Equiv	Breath Test 1 Sample 1	 Sample 2	Breath Test 2 Sample 1	 Sample 2	Breath sample nearest blood/urine	Sample Difference Test 1	 Test 2
C/01				060	000				060	
C/02				090	111				021	
C/03				101	069				032	
C1/02	B	185	80	086	037			higher	049	
C1/03	B	163	71	254	069			lower	185	
C1/05	B	233	101	116	095			lower	021	
C1/08	B	205	89	065	092			higher	027	
C1/09	B	086	37	028	048			lower	020	
C1/10	B	323	140	143	115			higher	028	
C1/11	B	131	57	054	033			higher	021	

†Breath Alcohol Concentration

Table A37 CAMIC BREATH ANALYSER Difference between two breath samples expressed as percentage of the lower sample – 1st and 2nd breath tests

Difference (%)	Frequency			Relative Frequency (%)	Cumulative Frequency (%)
	1st Breath Test	2nd Breath Test	Total		
0	240	5	245	13.1	13.1
1	166	5	171	9.1	22.5
2	303	8	311	16.5	39.0
3	194	6	200	10.6	49.6
4	205	3	208	11.1	60.7
5	173	3	176	9.4	69.8
6	112	2	114	6.1	75.9
7	110	6	116	6.2	82.1
8	64	1	65	3.5	85.6
9	64	1	65	3.5	89.1
10	39	0	39	2.1	91.2
11	36	0	36	1.9	93.1
12	21	1	22	1.2	94.3
13	23	1	24	1.3	95.6
14	9	1	10	0.5	96.1
15	7	0	7	0.4	96.5
16	12	1	13	0.7	97.2
17	8		8	0.4	97.6
18	10		0	0.5	98.1
19	2		2	0.1	98.2
20	2		2	0.1	98.3
Over 20	32	1	33	1.7	100.0
TOTALS	**1832**	**45**	**1877**		

Table A38 CAMIC BREATH ANALYSER Occurrence of the higher breath sample result within a breath test

	Frequency	Percentage
1st result higher	1026	56.0
Results equal	239	13.0
2nd result higher	567	30.9
	1832	